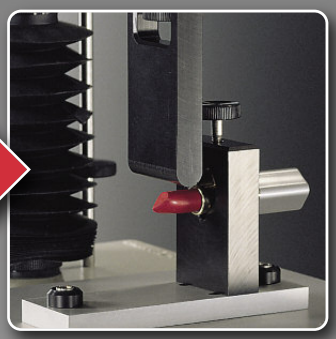
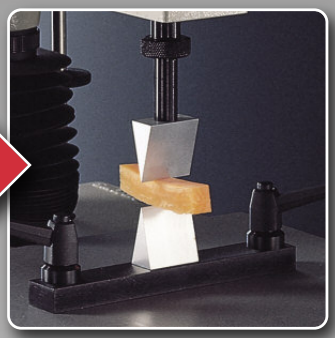










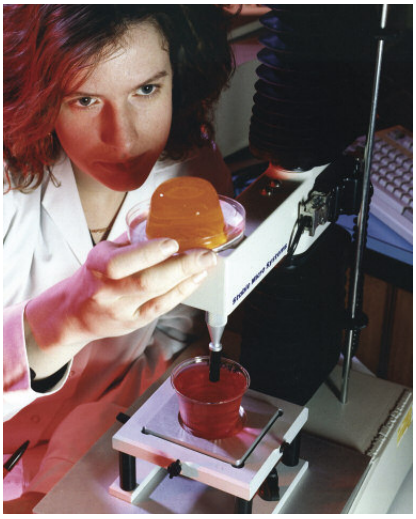
Measuring Textural Properties




Stable Micro Systems

Contents

Introduction



There is a vast range of physical properties which can be measured by a texture analyser.

In the quest for a more attractive new product and having due regard to the need for ease and economy of manufacture, there are few areas of research which can be more useful to the development team than texture analysis, bringing as it does the ability to compare many options with great accuracy. And the same applies when it comes to maintaining standards once production is under way.

This document details many of the properties that you may need to quantify in the development and manufacture of your product line. We hope that you will find it useful.

"... a vast range of physical properties..."

1 Properties measured in Compression

FIRMNESS/HARDNESS/SOFTNESS

These are textural properties that are generally on the same property spectrum.

A **soft** product is one that displays a slight resistance to deformation, a **firm** product is one that is moderately resistant to deformation and **hardness** describes a product which displays substantial resistance to deformation. However, it is also found that, depending upon the product industry, one of these words may be more favourable or pertinent to a particular product.

FIRMNESS/HARDNESS/SOFTNESS is the textural property commonly possessed by most products, although the word 'firmness' is often substituted for a textural property more associated with the product – e.g. toughness of meat.

Whilst **Firmness/Hardness/Softness** is a descriptive term that has no standard scientific definition in Texture Analysis, it is conventionally accepted as being either the force at the maximum distance of a compression cycle (e.g. puncture test on butter), or the maximum force reached prior to a fracture (e.g. biscuit break or puncture through skin of an apple).

Hardness can also be the force required to deform a product to a given distance. However, firmness/hardness can only be compared at the same distance of compression/penetration. Sometimes the maximum force may not be the most reproducible section of the curve (especially if this is the point at which a rupture occurs, for instance in a gel penetration test). The force at a chosen earlier distance before rupture may then be taken as a more repeatable representation of firmness/hardness.

Related properties:

TOUGHNESS: Whilst firmness/hardness is commonly the textural property possessed by most products, the word 'toughness' may often be substituted to describe a textural property more associated with the product, e.g. toughness of meat.

Look at Hardness as the effort you use to push your shopping trolley

Properties measured in Compression

FIRMNESS/HARDNESS/SOFTNESS

round the supermarket. The 'Hardness' to push it is dependent on the shopping being added. The more shopping you put in, the harder it is to push, i.e. the greater force you have to apply. The Toughness, or Work, is the accumulated effort of the whole journey around the supermarket from empty trolley to the checkout!

The descriptions Tenderness and Toughness are not absolute. They have to be defined by agreement between the parties using them. Tenderness maybe the inverse of toughness, as perhaps softness is the inverse of hardness.

SPREADABILITY, BITING FORCE/CUTTING FORCE, RUPTURE FORCE, COMPACTION FORCE/COMPRESSIBILITY and CONSISTENCY are all also related to the Firmness/Hardness of a product and are covered separately later.

Methods & Equipment for Measurement:

- Compression probes
- Penetration probes
- Multiple compression/penetration probes
- Back Extrusion Rig
- Knife blades of all varieties

"The more shopping you put in, the harder it is to push..."

In certain cases, the product has limitations of presenting to the texture analyser for testing. For these reasons, a compromise solution may have to be found to optimise the testing of the required product property. The choice of method and equipment for measurement will depend upon several factors, such as:

- Is your product self-supporting? (i.e. can it be tested outside of a container?)
- Even if your product is self-supporting, do you want to test it inside its container?
- Is your product repeatable in terms of size and shape?
- Is your product non-homogeneous, i.e. does it have particulates etc.?
- What type of test did you have in mind?

Properties measured in Compression

FIRMNESS/HARDNESS/SOFTNESS

"the sample must be repeatable in size and shape..."

Compression

The physical nature of some products make them more suitable for testing via a compression test. Generally the higher the force to compress (taken at the maximum force, or a suitable distance prior to the maximum force) the firmer the sample. For the repeatable assessment of products using a compression test, the sample must be repeatable in size and shape, as a compression test (by rule) completely encloses the product (although the AACC bread method is an exception to this). Where sample pieces are not so repeatable in size and shape (or are non-homogeneous), a number of pieces may be taken and tested together in a 'bulk compression' test. This serves to create an averaging effect.

A compression test may be chosen over a penetration test in some cases. One reason would be the presence of particulates/inclusions in a product. Penetration tests generally use small cylinder/ball/cone probes. They have a small surface area for testing and as such are more affected by non-uniform product structures. A compression test (generally using larger cylinder probes) serves to create an averaging affect, due to its larger surface area for testing. A stress relaxation test (measuring springiness, elastic recovery) should be a compression test where the whole sample is held under a compression probe. A penetration test produces a hole in the product and does not therefore allow the product to recover as in a small deformation compression test.

Bulk compression

Where a high force instrument is available, better repeatability may be provided by testing the sample 'in bulk' (i.e. the testing of a number of pieces or chosen weight of sample for each test.) This is especially suitable for those products that are not repeatable in size or shape and/or are non-homogeneous. Bulk compression tests are usually performed using an Ottawa Cell or Kramer Shear Cell.

Properties measured in Compression

FIRMNESS/HARDNESS/SOFTNESS

Penetration

The physical nature of some products make them more suitable for testing via a penetration test. Generally the higher the force to penetrate, the firmer the sample. A penetration test may often be chosen over a compression test for the following reasons:

a) Where the product is not repeatable in size and shape, but has a certain repeatable facet of its surface to which a small penetration probe can repeatedly be applied. For example, in the testing of an apple, apples are not normally perfectly identical in size and shape. By using a penetration probe to test, the apple could have a diameter of e.g. 60-300mm without any effect on the repeatability of the test.

b) Where assessment of the internal structure of a product is more desirable. A penetration test, by its nature, probes through a product (producing a hole in its path). Sometimes small cylinder probes/needles are used to assess, for instance, the aerated or laminated structure of a baked product, as they are effectively more sensitive than a test which crushes (compresses) the whole sample.

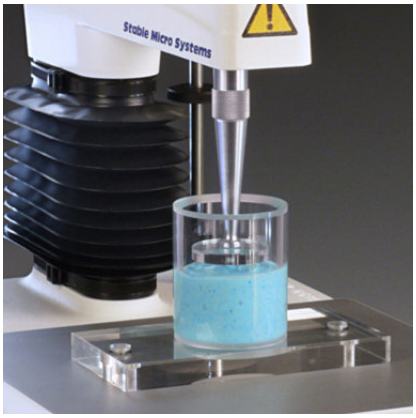
c) A smaller cylinder probe reduces the measured force if a test exceeds the load cell capacity, e.g. for hard candy, and may be, for some products, the only possible way to test given a force limitation situation.

"generally the higher the force to penetrate, the firmer the sample..."

Rupture Force and **Gel Strength/Bloom Strength** are characteristics that can be measured during a penetration test (and are covered separately in more detail later).

Properties measured in Compression

FIRMNESS/HARDNESS/SOFTNESS



Extrusion

The physical nature of some products make them more suitable for testing via an extrusion test. This test is obviously limited to those products that can be extruded (i.e. generally fluid products) and is naturally unsuitable for such 'dry' products as e.g. breakfast cereals and bread. Generally the higher the force to extrude, the firmer the sample.

Cutting

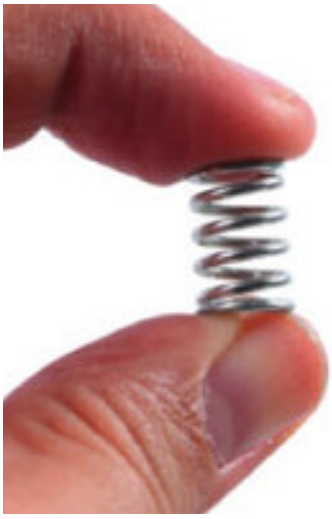
The physical nature of some products make them more suitable for testing via a cutting test. Generally the higher the force to cut/shear, the firmer the sample.

Bending

The physical nature of some products make them more suitable for testing via a bending test. Generally the higher the force to bend (usually up to the point of break), the firmer the sample.

Properties measured in Compression

SPRINGINESS



SPRINGINESS is the rate at which a deformed material goes back to its undeformed condition after deforming force is removed. It is a measurement of elastic recovery.

It is commonly the textural property possessed by baked goods such as cake or bread but also possessed by novel confectionery products and pharmaceutical materials (e.g. cosmetic sponges).

The Texture Analyser can be used to partially compress a product to a distance and over a chosen period of time the attempted recovery of the product can be monitored. By tracking the force given back from the product after initial compression a calculation can be made to see how close the product is to a 'perfect spring'.

Methods & Equipment for Measurement:

- Large cylinder probes
- Platens

"A measurement of elastic recovery..."

Properties measured in Compression

GEL STRENGTH

"Bloom... the force... necessary to depress by 4mm the surface of a gelatine gel with a standard 0.5" diameter cylinder probe..."

GEL STRENGTH is a measure of the ability of a colloidal dispersion to develop and retain a gel form.

In the gelatine world, gel strength is traditionally referred to as Bloom. It is the force, expressed in grams, necessary to depress by 4 mm the surface of a gelatine gel with a standard 0.5" diameter cylinder probe.

Whilst gels are commonly accepted in the food industry, the measurement of gel strength is also of widespread interest in the manufacture of pharmaceutical, medical and cosmetic products. Gel properties such as elasticity and rupture force of, for example, pectin, gelatine, agar etc., are important in the development of such products as coronary stents, where hydrogel polymers are selected due to their soft, rubbery nature which gives them a strong, superficial resemblance to living, soft tissue.

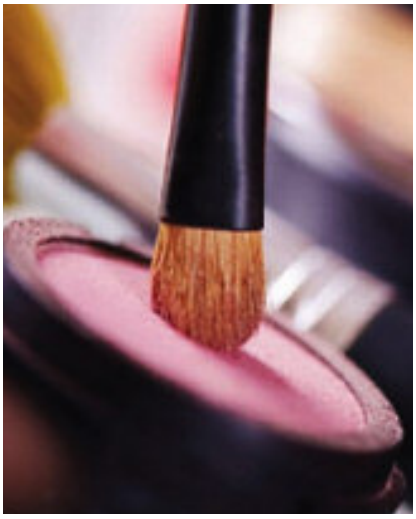
Other areas where gel-forming properties are useful are in the manufacture of wound dressings, jelly lubricants, contact lenses, suppositories, soft gel capsules and bacterial growth media. The strength of gels can also be utilised in products such as toothpaste, creams and pastilles to modify the consistency of the required end product.

Methods & Equipment for Measurement:

- Hemispherical probe
- Cylinder probes

Properties measured in Compression

COMPACTABILITY/COMPRESSIBILITY



This is the ability of a product to be compacted or compressed, usually to a large degree of deformation.

This can be a required property in, for example, the formation of cosmetic powder tablets or formation of tablets from granules. However it may also be undesirable, as would be true of a large proportion of packaging material, which is usually chosen for its ability to protect a product and therefore resist compaction to a reasonable extent.

Methods & Equipment for Measurement:

- Cylinder probes of all sizes

"the ability of a product to be compacted or compressed..."

Properties measured in Compression

BITING/CUTTING FORCE

BITING/CUTTING FORCE gives an indication of the firmness/hardness of a product.

If one considers that the top front teeth were pulled from a curve-shape into a straight line they would represent a 'knife edge'. Using a knife blade gives a close representation of the biting or cutting action.

TOUGHNESS is commonly the textural property possessed by meat, fish and poultry products, but also used for baked products such as tortillas, pancakes or pizzas. The toughness is often taken as the total positive area under the curve. This measurement effectively records the total 'work' involved in performing this test; it therefore follows that a higher area value indicates a higher amount of energy involved in performing the test and subsequently is translated as a tougher sample to test.

Methods & Equipment for Measurement:

- Blades and craft knives

Stable Micro Systems' range of blades vary considerably in size, material, thickness and sharpness. In general they measure the Bite/Cutting Force of products which in some instances can relate to their 'Toughness'.

When a product is uniform (homogenous) a single blade test may be adequate for the repeatable assessment of the product. However, quite often, a product is non-uniform (heterogeneous) in make-up. For example, cereal bars are of different structure throughout their length. A single cutting test may encounter a peanut, toffee piece and hard wheat piece. The same cutting test done further down the length of the product will produce a different result; this time the blade may encounter a fruit piece and a chocolate chip. The same type of explanation can be given for a piece of meat. To assess these types of product in a more reproducible way, the recommendation is to perform a multiple shearing test (most often using a Kramer Shear Cell). This test performs 5 or 10 cutting tests within one test and therefore creates an averaging effect.

Note: The majority of tests using a Kramer Shear Cell require a loadcell capacity exceeding 50kg.

Properties measured in Compression

RUPTURE FORCE

"Rupture force measurement can be crucial..."

RUPTURE FORCE can be related to the firmness of a product. It is the force that is required to produce a major break/rupture in a sample.

It is related to burst force which is the force causing the product to come apart suddenly and violently into pieces.

Rupture force measurement can be crucial for such products as medical implants which may be required to resemble soft tissue but must remain intact for the duration of their intended residence. Several other products, such as gel capsules containing vitamins, possess bursting as a desirable property but must withstand transport and handling before ultimately bursting in the mouth.

Methods & Equipment for Measurement:

- Cylinder probes
  (usually of larger diameter than the sample being tested)

Properties measured in Compression

FRACTURABILITY/BRITTLENESS

FRACTURABILITY/BRITTLENESS is an expression of the force with which a material fractures, crumbles, cracks or shatters (usually displayed by a product of high degree of hardness and low degree of cohesiveness) and is related to brittleness.

It is commonly the textural property possessed by baked goods, snacks and generally 'dry' products. Fracturability encompasses crumbliness, crispiness, crunchiness and brittleness. A material is brittle if it is liable to fracture when subjected to stress. That is, it has little tendency to deform (or strain) before fracture and usually makes a snapping sound.

The usage, including eating, of foods normally involves large deformations. Fracture and/or yielding then become the salient features. During deformation of a more or less solid material, local stresses and strains are always highest near inhomogeneities; fracture starts near or at such places. During fracture these defects grow, new surfaces are formed and the material ultimately falls into pieces.

Fracture starts if the local stress is higher than the adhesive or cohesive forces in the material at that place. It propagates spontaneously if the deformation energy that is released when the material fractures is at least equal to the energy needed to create new surfaces. Both processes, fracture initiation and propagation, depend on the presence of defects; larger defects cause fracture to occur at lower overall stresses and strains.

"...usually displayed by a product of high degree of hardness..."

Methods & Equipment for Measurement:

- Cylinder, needle, cone and spherical probes
- 3 Point Bend Rig
- Crisp Fracture Support Rig
- Knife Blades
- Lipstick Cantilever Rig
- Spaghetti Flexure Rig

Properties measured in Compression

FRACTURABILITY/BRITTLENESS

In most materials, **peak force** is usually the start of fracture. The force then falls either to zero if fracture is complete, or falls partially if fracture is incomplete. Fracture does not always start at the highest point on the curve but usually the start of fracture is recorded as a peak on the curve. During a test it is important to visually monitor the start of fracture.

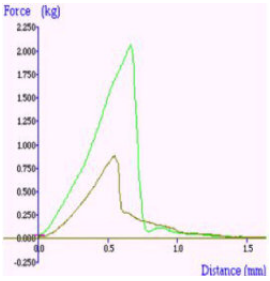
FRACTURABILITY (single break) is usually represented by a characteristic sharp curve (usually a thin triangle shape). In a curve such as that shown below, the following are often recorded:

- Distance at break = 'fracturability'/'brittleness' (mm)
- 'Force at break' = 'hardness' (g/kg)
- Gradient of slope = 'toughness'/'stiffness' (g/mm)

See **Crispness/Brittleness** for the assessment and analysis of multi-peak 'jagged' curves.

FLEXIBILITY is the opposite of this and is a characteristic of a product that can be bent, flexed or deformed to a much higher degree of deformation before failing.

STIFFNESS is associated with a material that cannot easily be bent and therefore has a high degree of hardness and usually lacks flexibility.



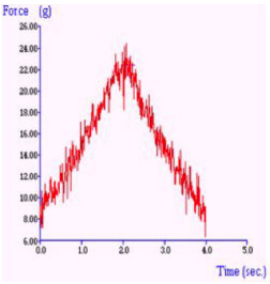
" the start of fracture is recorded as a peak on the curve..."

Properties measured in Compression

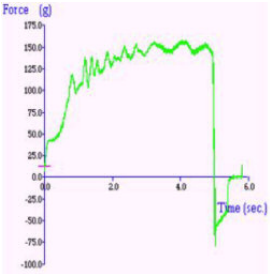
CRISPNESS/CRUNCHINESS/BRITTLENESS

This is a property manifested by a tendency when subjected to an applied force to yield suddenly with a characteristic sound.

It is commonly the textural property possessed by snacks (potato chips), breakfast cereals, fresh fruit and vegetables and some baked products (biscuits, crackers). These types of products are usually associated with sharp triangular curves displaying an obvious break point (when tested individually) or produce a 'jagged' multi-peak curve when tested 'in bulk'. The number of peaks produced are as a result of the fracture events that have occurred during the test. Counting the number of peaks, the average dropoff and measuring linear distance are common calculations applied to such curves. Crispness is usually associated with many small fracture peaks. Whilst a crunchier product may possess the same number of curves the drop from peak to trough will be significantly higher and the linear distance increased accordingly.



E.g penetration of gelatin gel using 25kg load cell



E.g. lipstick penetration highlighting the unwanted presence of air pockets

Methods & Equipment for Measurement

Single pieces of homogenous product:

- Three Point Bend Rig
- Knife blades
- Small Cylinder probes

Multi-particulate or non-uniform products:

- Ottawa Cell
- Kramer Shear Cell

Considerations

Not to be confused with 'noise' when very low force is measured on a high capacity load cell, e.g. measuring gelatine bloom strength of approx. 25g on a 25kg load cell

Fluctuating force curves may also be due to:

- air pockets e.g. aerated spreads, mousse
- presence of hard particulates e.g. yoghurt (fruit pieces), lipsticks (grainy undissolved colourants)

Properties measured in Compression

SPREADABILITY

"It is related to the firmness of a product..."

SPREADABILITY is the ease of which a product can be spread.

It is commonly a desired characteristic of margarines, butter, jams, chocolate spreads, etc. but is also an important characteristic of ointments, creams and waxes. It is related to the firmness of a product and more often than not the ease of spreading is associated with a loss in firmness.

Methods & Equipment for Measurement

- Spreadability Rig

Properties measured in Compression

ACTUATION FORCE

"...test typically uses a hemispherical probe..."

ACTUATION FORCE testing allows measurement of the force required to, for example, release hair fixatives or air freshening sprays from aerosols, liquid soap, shampoo or cream from dispensers.

Manually-actuated spray pump dispensers or finger pumps rely on the consumer to generate a hydraulic pressure in the pumping engine in order to dispense the fluid. Dispenser designs may change or vary, or the ever-increasing market for child-friendly products may require adaptations.

When operating a pump-type liquid soap dispenser, for example, a child may have difficulty applying sufficient force in the appropriate direction to operate the pump, which may cause the dispenser to move, tip, or otherwise fail to discharge the product toward the intended target. An actuation force test typically uses a hemispherical probe to apply the force and provides an imitative test to assess such issues.

Drug delivery can also be as a result of actuation. A metered dose inhaler (MDI) delivers a precise, reproducible dose of drug accurately to the deep lung. It is also well accepted by patients who depend on MDI's in their treatment and therefore it is essential to constantly improve this technology. Patients need to rely on their inhaler to provide them with the required medication which is often at a crucial time when physical strength may be very low.

The metering valve, whose performance is assessed with this test, is a critical component of a finished metered-dose inhaler. The interaction between the elastomeric components and the formulation can significantly affect product performance. A change in formulation, for example implementing a new propellant system, may necessitate a complete redesign of the valve system in order to successfully deliver the drug with the minimum of difficulty.

Properties measured in Compression

ACTUATION FORCE

Measuring actuation force does not always apply to the delivery of a product as a result of the actuation, but is also applicable to the testing of, for example, buttons for mobile phones, cameras, etc. or defining the life of a membrane switch. It is important that the switch or button under test be pressed with a force hard enough to achieve switch contact closure or the actuation of a motion.

Methods & Equipment for Measurement

- Hemispherical probe
- Inhaler Support Rig

"a force hard enough to achieve switch contact closure ..."

Properties measured in Compression

SWELLING

SWELLING is associated with an increase in size or volume of a product.

Swelling applications include tablets, gels, films, pellets, mucosal tissues, super-absorbent polymers, sponges, aquaculture feed, chemical and yeast leavened products, etc.

Depending on application, swelling can be quantified by measuring changes in force or distance by either (i) compressing a product a slight distance and then measuring how force increases as the product swells, or (ii) applying and maintaining a small force onto the product and measuring the distance change as swelling occurs.

The Texture Analyser can be used to monitor the change in height of a product from its original height over a period of swelling or volume/height increase. By tracking the distance required to move to maintain a chosen force, the rate of decay can be plotted and calculated to the end point or period of no further change.

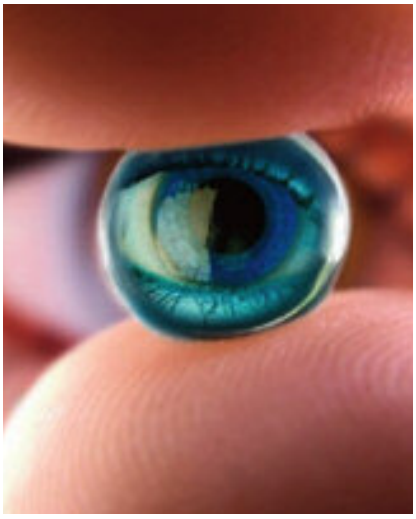
If the product is likely to expand horizontally, then it should be constrained to focus the swelling forces and expansion vertically.

"swelling can be quantified by measuring changes in force or distance..."

Swelling behaviours are typically activated by the introduction of a solution or heat (e.g. leavening). The most complicated element is how to stage the consistent introduction of the catalyst at exactly the desired time. Typically, for example in tablet swelling measurement, an exact amount of liquid at a desired temperature is pipetted directly into a container at a fixed time before or simultaneous with the initiation of the test. Some materials will require the continued introduction of the swelling catalyst during the test in order to achieve the maximum swelling. In such occasions the fixtures may have built-in reservoirs to draw from, or the test protocol can call for reintroducing liquid at certain times during the test.

Properties measured in Compression

SWELLING



Among the measurements which can be obtained are: the initial rate of swelling; maximum amount of swelling and length of time to occur and the swelling rate as the product was saturated.

Texture Analysis can be used to measure the swelling of gels and gel coatings, allowing scientists to determine the time before the gel dissipates and active ingredients become available.

Gel layer thickness is generally regarded as one of the key parameters affecting the release from swelling-controlled matrix systems. An increase in gel thickness of the rate-controlling polymer will lead to a declining release rate, irrespective of system geometry.

Sophisticated microscopic techniques and nuclear magnetic resonance imaging have been used to monitor these changes, but these analyses, though highly accurate and sensitive, are time consuming and difficult to perform. The TA.XT*plus* texture analyser is able to provide easy and accurate determination of dimensional changes associated with matrix hydration and swelling of complex formulations and results compare well to NMR imaging.

Methods & Equipment for Measurement

- Large platens and cylinder probes

"can be used to measure the swelling of gels and gel coatings..."

Some products may need to be tested as a whole or within a vessel – where possible, a more accurate measurement can be made by the use of as large a diameter probe as possible to provide as large a surface area as possible. Sometimes, however a swelling front may need to be monitored such as tablet film swelling. In this instance a 2mm cylinder or needle probe is used.

Properties measured in Compression

DISINTEGRATION

DISINTEGRATION is the ability to become reduced to components, fragments, or particles.

It may be as a result of decay, loss of cohesion, dissolving or crumbling and is generally associated with shrinkage, loss of height or volume from its original form. It is one of the primary characteristics of bath bombs, fast-disintegrating tablets, whipped creams, foams and mousses.

The Texture Analyser can be used to monitor the change in height of a product from its original height over a period of disintegration or volume/height loss. By tracking the distance required to move to maintain a chosen force the rate of decay can be plotted and calculated to the end point or period of no further change.

Methods & Equipment for Measurement

- Large platens and cylinder probes

These types of products tend to be low force applications and therefore a more accurate measurement can be made by the use of as large a diameter probe as possible to provide as large a surface area as possible.

"the rate of decay can be plotted and calculated..."

Properties measured in Compression

CONSISTENCY & EXTRUDABILITY

"until the structure of the product is disrupted..."

CONSISTENCY is the textural property possessed by dairy products, sauces, syrups and pharmaceuticals lotions (i.e. fluid products).

It most often makes use of the back extrusion rig for its measurement. Consistency relates to the 'firmness', 'thickness' or 'viscosity' of a liquid or fluid semi-solid. Stirring a fluid or semifluid food with a spoon or a finger is frequently used to measure viscosity or consistency.

EXTRUDABILITY is a measure of the power required to push or force something out of something.

A compression-extrusion test consists of applying force to a product until it flows through an outlet (or number of outlets) that may be in the form of one or more slots or holes that are in the test cell. The product is compressed until the structure of the product is disrupted and it extrudes through these outlets. When quantifying extrudability, is important to determine the ease of removal and application of products such as ointments, creams, gels, sauces, paint, icings, etc.

Product developers can analyse changes in a product's consistency throughout its shelf life and adapt formulations accordingly, whilst also enabling manufacturers to assess the suitability of packaging material and its construction.

Methods & Equipment for Measurement

- Back Extrusion Rig
- Forward Extrusion Rig
- Toothpaste Extrusion Rig
- Sachet/Tube Extrusion Rig

Considerations

Sometimes the product may possess particulates. These will affect the repeatability of the results, as a different number of particulates will come into contact with the extrusion disc for each back extrusion test, for example. If the product cannot be tested without the inclusion of particulates, it is recommended to use a larger container and larger extrusion disk for assessment. This effectively increases the volume of product tested under the surface and therefore serves as an averaging effect.

Properties measured in Compression

SYRINGEABILITY

SYRINGEABILITY can be considered to be the ability of a product to be successfully administered by a syringe and appropriate needle.

Syringes are used in hospitals, surgeries and homes around the world on a daily basis, and for a multitude of purposes. Successful administration, as well as comfortable receipt of the material under the skin, rely on the effective tracking of the syringe piston within its outer tube. By testing the ease with which an injectable solution is expressed, manufacturers are able to optimise usability and patient comfort, while guaranteeing quality control and product safety.

Prior to testing, the syringe is held securely in place by a clamping support, which is easily adjusted up to a diameter of 50mm and accommodates a wide range of syringe shapes and sizes. The arm of the TA.XT*plus* exerts pressure on the syringe piston, measuring its resistance to compression. Using *Exponent* software, a mean force is produced in graph form to provide an average measure of the ease with which the syringe is depressed and fluids are discharged.

The universal design of the Syringe Testing Rig also allows manufacturers to determine the force required to remove the plunger from the syringe, thus emulating the ease with which the syringe piston is withdrawn.

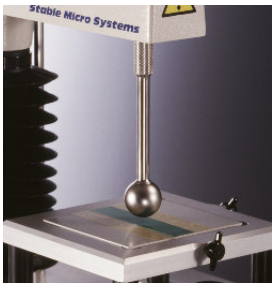
"manufacturers are able to optimise usability and patient comfort..."

Methods & Equipment for Measurement

- Syringe Testing Rig

2 Properties measured in Tension

STICKINESS/ADHESIVENESS



"Stickiness in foods such as rice can be a positive feature..."

This is the work/force necessary to overcome the attractive forces between the surface of the product and the surface of the material (the probe) with which the product comes in contact.

It is commonly the textural property possessed by confectionery products, cooked pasta products, raw bakery products, pharmaceutical patches and, more obviously, adhesives.

TACKINESS is the property of being cohesive and sticky. It does not appear to be referred to in the food industry but their are lots of references in e.g. solder paste measurement for printed circuit board industry.

Stickiness/Adhesiveness is a desirable and sometimes vital characteristic when wishing to stick two surfaces together, e.g. for the adherence of coatings, films, attachment of adhesive and medical tapes or drug delivery devices for semi-permanent or permanent applications. However, it can be an extremely undesirable characteristic in such examples as confectionery wrappers attaching to the enclosed confectionery, or chewing gum to shoes, furniture etc. Stickiness is a major problem in the food industry, especially in the baking and confectionery industries, where it can cause considerable difficulty during processing by causing interruptions in production, waste and contamination of machinery.

Stickiness can potentially be both a negative and a positive characteristic of foods. It is an expected characteristic of many foods provided that excessively high levels are not reached, for example in soft cookies, toffees and dried fruit and, in some dishes, such as sticky toffee pudding, relatively high levels are required. Stickiness in foods such as rice can be a positive feature in some cuisines, for example in oriental rice dishes or in Italian risotto, but is regarded as unacceptable in Western cuisine.

Properties measured in Tension

STICKINESS/ADHESIVENESS

"even moderate levels of stickiness can reduce product eating quality..."

In general, however, stickiness finds more usage as a negative term than as a positive term, perhaps reflecting the difficulty in avoiding high levels in some common foods. This can be seen with foods such as rice and pasta, in which even moderate levels of stickiness can reduce product eating quality. This is particularly the case with many sugar confectionery products and with the handling of chocolate products, especially at high ambient temperatures. Sticking of food to packaging materials is generally regarded as undesirable, resulting in possible packaging material damage, product loss and disfigurement of the product surface. It can be surmised that the extent to which this could generate adverse consumer reaction will depend on the extent of the sticking, on the type and cost of the product and on the availability of alternative product/packaging combinations.

Methods & Equipment for Measurement

- All sizes of cylinder probes, hemispherical and ball probes.

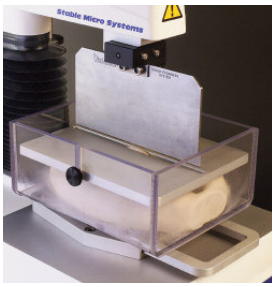
Specialist fixtures such as the Tablet Coating Adhesion Rig, the Confectionery Holder, the Flexible Substrate Clamp, the Warburtons Dough Stickiness System and the Pasta Firmness/Stickiness Rig have all been designed with the purpose of holding down the sample in order to test the adhesiveness successfully.

Considerations

When measuring adhesiveness it is of utmost importance to make sure that the surface of the probe that is used is cleaned thoroughly. Failure to do this will affect the results. The adhesive product must also be held down in some way in order to successfully measure the separation of its surface and that of the contacting probe. The testing probe should not 'lift' the product during the test. As well as the specialist fixtures that have been specifically designed to cope with this issue, simple solutions to this have also been found in literature. Preparing gels on velcro, attaching packaging material to the end of a probe and glueing down the test sample to a disposable surface are all typical examples.

Properties measured in Tension

STICKINESS/ADHESIVENESS



There are many factors that affect the measurement of stickiness such as: test geometry, sample dimensions, probe material, probe dimensions, surface condition, contact force, contact time, separation rate, temperature and sample rheology.

It is also commonly known that the probe material substantially affects the results obtained – once a probe is chosen for a test, the material type and surface finish (e.g. polish) should not be changed.

Failure Mechanisms

The formation of an adhesive bond between adhesive and adherend is an essential component of stickiness, but the mode of failure on separation is also of great importance. True adhesive failure occurs if there is a clean failure of the bond between adhesive and adherend, with no residual adhesive remaining on the adherend surface. If adhesive does remain on the surface, cohesive failure within the adhesive has occurred.

"the probe material substantially affects the results..."

Properties measured in Tension

PEEL STRENGTH

PEEL STRENGTH is a material's ability to resist forces that can pull it apart by separating a flexible surface from a rigid surface or another flexible surface.

Usually the average force per unit width and the peak force required to separate either of these two surfaces is measured.

Peel tests are useful for a variety of products and can be performed on containers such as jars, cans, trays, packaging pouches as well as assessment of adhesive, cosmetic and medical products such tapes, bandages, wax strips etc. The most common tests are the T-peel, 90 degree peel and the 180 degree peel but different peeling angles are possible.

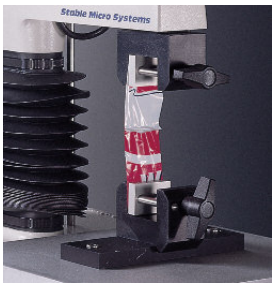
Methods & Equipment for Measurement

- All Peel Rig fixtures

"a material's ability to resist forces that can pull it apart..."

Properties measured in Tension

TENSILE STRENGTH



" three typical definitions of tensile strength..."

TENSILE STRENGTH is the measure of the force or stress required to pull something (resistance to lengthwise stress) to the point where it breaks or before permanent deformation results.

Usually it is the maximum amount of tensile stress that it can be subjected to before failure although the definition of failure can vary according to material type and design methodology.

In the fields of material science, mechanical engineering and structural engineering there are three typical definitions of tensile strength:

Yield strength: the stress at which material strain changes from elastic deformation to plastic deformation, causing it to deform permanently.

Ultimate strength: the maximum stress a material can withstand.

Breaking strength: the stress coordinate on the stress-strain curve at the point of rupture.

Tensile Strength can relate to the Toughness of products. The higher the tensile strength a product possesses the more difficult or tougher it is to stretch. This property can be a positive feature in some products, for example in rope and rubber bands to an extent, but is regarded as unacceptable or negative in chewing gum, mozzarella cheese, noodles or christmas crackers.

Methods & Equipment for Measurement

All probes that allow successful holding of a product in order to test in a tensile manner.

Properties measured in Tension

TENSILE STRENGTH

Considerations

The challenge for peel tests is how to grip the product. Many materials are too fragile to grip, so the sample is mounted on some plate and the opposite material is peeled off from it. The samples can be mounted on a metal plate or glass slide with contact glue, stiff double-sided tape or left by themselves (only if the peel forces are very low).

Extremely fragile films, for example, can be mounted on paper, cardboard or gauze frames, which help handle the samples up until the peel test is commenced. Right before each test, the frame should be cut so as to not interfere with the release behaviour.

"how to grip the product..."

Properties measured in Tension

EXTENSIBILITY/ELONGATION

EXTENSIBILITY/ELONGATION is the degree (distance) to which a product can be extended/stretched before breaking.

It is related to the 'elasticity' of a product. It is commonly the textural property possessed by raw baked goods (e.g. dough, pastry), cooked baked goods and pasta (e.g. pancakes, tortillas, noodles), but can be a novel property of confectionery products (e.g. liquorice, chewing gum).

Methods & Equipment for Measurement

- All probes that allow successful holding of a product in order to test in a tensile manner

"It is related to 'elasticity'..."

Properties measured in Tension

STRINGINESS/SHORTNESS & COHESIVENESS

STRINGINESS/SHORTNESS is the degree (distance) to which a product hangs on the probe when the probe is withdrawn.

It is a primary characteristic of mozzarella cheese or adhesives, but is commonly the textural property possessed by sauces (e.g. ketchup, dessert sauces), confectionery glazes, baked product toppings and, undoubtedly, syrups. In the adhesive industry this characteristic is sometimes referred to as 'legging', as stringiness may result in the formation of filaments or threads when the adhesive surfaces are separated.

Stringiness may be a desirable property, as is the case for mozzarella cheese or caramel decorations, but be considered undesirable for the application of paint where a 'short' texture is required for quick and clean removal of brushes from paint tins.

Methods & Equipment for Measurement

- Cylinder probes and platens
- Back Extrusion Rig
- Moderate/large Cylinder probe

"Stringiness may be a desirable property..."

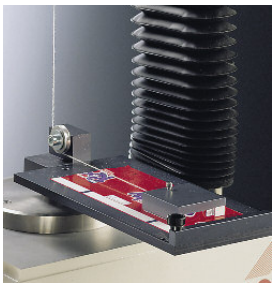
COHESIVENESS (Tensile) is the tendency of a product to cohere or stick together.

The intermolecular attraction by which the elements of a body or mass of material are held together determine its cohesiveness. It is related to the internal stickiness of a product, and is usually determined by measurement of the amount of force to remove an item from the product mass.

High cohesiveness may be favourable for products such as paint, where easy removal of a brush from the main mass of paint needs to be a clean separation and without the tendency to extend from the surface of the mass to the brush for a considerable distance. However, low cohesiveness may be a favourable property of a product such as honey or syrup, where considerable extension of the product from its main body of material is accepted.

Properties measured in Tension

FRICTION



FRICTION is a phenomenon that is part of our daily lives – in one sense we would find most difficult to survive without it yet in another it can be most expensive to minimise.

It can be simply identified as the resisting force that arises when one surface slides, or tries to slide, over another. It is commonly the textural property measured for packaging materials, shaving gels, cosmetic sponges, etc.

Friction can be a limitation to us; for example, the friction of packaging can be a major limiting factor in the speed of packing machines. Additives are often used to improve the lubricity of surfaces, this being known as 'slip'. Polythene is added to packaging to improve slip characteristics.

We recognise that there are two reactions due to friction that we can define. There is '**Static Friction**' (sometimes shortened to '**Stiction**'), that is the resistance to start relative movement and there is '**Kinetic**' or '**Moving Friction**' that is the resistance to maintain the movement at a specific constant speed. We can measure a coefficient of friction which is an empirical measurement. Rougher surfaces tend to have higher values.

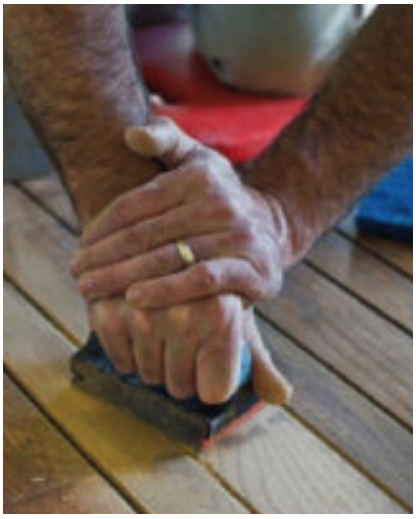
"Friction can be a limitation to us..."

Methods & Equipment for Measurement

- Friction Rigs

Properties measured in Tension

ABRASION



ABRASION is the erosion of material from a solid surface by the action of another solid.

When material is removed by contact with hard particles, abrasive wear occurs. The particles either may be present at the surface of a second material or may exist as loose particles between two surfaces.

Abrasive materials are widely used across a variety of industries for polishing, grinding, honing and other similar processes. The efficacy of these materials relies on their frictional properties, which can be calculated as the force required to draw the material across a given surface. Assessment of these properties will allow manufacturers to evaluate the suitability of their products for a specific use. The test results will also highlight differences between grades or brands of abrasive materials.

"the erosion of material from a solid surface..."

Methods & Equipment for Measurement

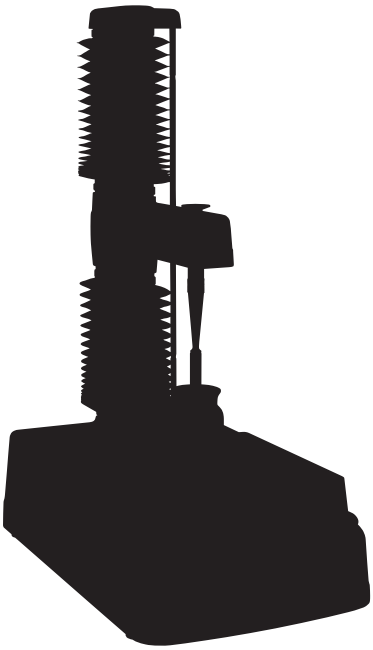
- Abrasive Test Rig

An Abrasive Test Rig analyses the frictional properties of a wide range of materials such as sandpaper, dental abrasive strips and flexible nail files, enabling manufacturers to highlight strengths, weaknesses and variations in product lines and materials. Prior to performing the test, a sample of the abrasive material is held in place in a self-tightening grip. As the test is carried out, the arm of the TA.XT*plus* or TA.HD*plus* draws the sample under and around a cylinder at 90 degrees and the force required to pull the material is recorded.

The cylinder material is customer-specific according to the substrate over which the sample is required to abrade. *Exponent* software is then employed to analyse the multi-peak force profiles obtained and apply special calculations to evaluate the frictional properties of the material. For coarse samples, a wider fluctuating force band will be recorded, while for the finer materials, a narrower force band can be expected.

As well as providing an accurate measurement of the frictional properties of the material, the results recorded can also be used to evaluate the stick/slip characteristics of the abrasive sample, by calculating the force difference between the maximum and minimum peaks obtained.

Conclusion



The world of texture analysis is one of constant development, and scientific discovery. Always advancing into new and often unexpected fields of testing, it is an exciting and absorbing area of research, and one which is also of considerable commercial importance.

Whatever your requirements, whether at the most complex end of the product development spectrum, or in the demanding if repetitive area of quality assurance, you need to think carefully about how you can achieve the best possible value for your budget. Bear in mind that the availability of in-depth education, specialised test design services and free testing advice is especially important as you start work on your early texture analysis projects. While there may be alternatives which are apparently cheaper, there is no real substitute for many years of scientific study, engineering development and ground-breaking software authoring.

In short, Stable Micro Systems' *Plus* Texture Analysers and *Exponent* software offer you a blend of capability, expandability and value for money which is quite simply unmatched anywhere in the world.

The Author

Jo Smewing has worked for Stable Micro Systems since 1994. She has managed the application laboratory, where she has developed specific texture analysis methods for the food industry.

Now, as Business Development Director, she heads the development team of the company, which involves co-ordination of electronic, software and mechanical engineers in the generation of new products.

Jo regularly writes magazine features across a range of industries including food, pharmaceuticals, cosmetics and adhesives and has published several papers based on texture analysis.

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