**Modern Food Packaging Technologies: Regulatory Aspects and Global Trends**

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**Week – 07**
**Lecture – 32**

Welcome to the NPTEL online certification course on Modern Food Packaging Technologies Regulatory Aspects and Global Trends. In the last class we have seen what is food packaging testing and how does food packaging testing works and we have also covered how to select the right packaging testing methods. And in the present lecture we will be discussing the measurement of tensile strength, tear resistance, resistance to abrasion and drop test. Now the tensile strength, it is a measure of films resistance to being pulled apart a constant rate of speed. Maximum load that material can support without fracture when being stretched divided by the original cross and sectional area of the material.

Tensile strength have dimensions of force per unit area and in the English system of measurement are commonly expressed in units of pounds per square inch often abbreviated to PSI. When stresses less than the tensile strength are removed the material returns to their completely or partially to its original shape and size. As the stress reaches the value of the tensile strength however, a material if ductile that has already begun to flow plasticity rapidly forms a constricted region called a neck where it then fractures. Tensile properties are an important and common way to compare physical properties of diverse materials from steel to plastic.

In the narrower rim of flexible films these test provide measurement of attributes we can see and feel strength, stiffness and resistance to stretching. The tensile strength of polypropylene increases sufficiently by the orientation process. Resin selection and orientation method are the primary variables that influence tensile values. Therefore, tensile properties are almost entirely defined by product design itself. Small variations in tensile will inevitably result due to normal process variation, but the performance effect it significant effect is insignificant.

Each end of a film specimen of specific width and measured thickness is held by a clamp or grip. One grip is stationary while the other is pulled away from the first at a preselected velocity. The machine continuously measures the changing distance between the grips and the force exerted the film apart. The test is completed when the sample breaks. This picture denotes the elongation when the stress is applied then this region the slope of this represents the modulus of elasticity up to the point which is

known as yield strength.

And if the stress is continued or the force is continued to apply then it will go to its maximum force where the necking begins and that is the tensile strength. And after that if force is applied then the local necking starts and if the force is continued then it breaks. Now, the dynamic tensile strength this measures the energy required to break a specimen of specified dimension by subjecting it to an impact stress. The paper is clamped in a sigmoid shape. A pendulum is released to cut the paper.

This test is important for construction of multi wall paper bags as it gives an index to the capacity of the sample to absorb impact shock. Now the tear resistance. Tear resistance is the force necessary to continue tearing a sample after a nick has been made. This test is very important for all films as well as for paper. High tear values may be needed for machine operations or for package strength.

However, low tear values are necessary and useful for easy opening of some package types. Tear strength is reported in grams. Tear test is of two types, edge tearing and internal tearing. A tear tester is a stationary clamp and a movable clamp on a pendulum means for holding this pendulum in a raised position then quickly releasing it and a scale that resistors the arc through which the release pendulum swings. Samples of paper or film are clamped into the tester and knicked to start the tear then the pendulum clamp is released.

This tears the sample and the scale resistors the arc. As the arc is proportional to the tear strength of the sample calibration of the arc gives the tear strength. Tear test is of two types, edge tearing and internal tearing. Internal tearing is most frequently used for measuring the tear resistance of papers and plastic films. The tear resistance depends on the type of packaging material, physical properties, processing method and the condition of testing.

An instrument named Tear ASTM D 1922 is most widely used for measuring tear resistance. Types of tear testing, some of the common types of tear testing along with the brief explanation of each test and the associated standards are described below. Trousers tears are single rip test. This method involves cutting the specimen into a trouser like shape creating a small tear and then pulling the legs apart to propagate the tear and the standards used are ASTM D 1938 for the plastics and ISO 341 for rubber. The another test is Tongue Tear or Double Rip Test.

A specimen is cut into a tongue like shape and pulled in two directions to propagate a tear and the standards used are ASTM D 2261 for textiles and ISO 139372 for textiles.

Wing tear are the grave test. The specimen is prepared in a specific rectangular shape with a notch and pulled apart to measure the force to continue the tear and the standard is ASTM D 624 for rubber. The wing tear are Winkleman test similar to graves, but with a different geometry and notch orientation. Specific standards may vary often used in conjunction with other methods.

Trapezoidal Tear Test. This involves cutting the specimen into a trapezoidal shape and pulling and pulling it apart from the nosed area to propagate the tear and standards used are ASTM D 5587 for textiles and ISO 90734 for textiles. Baumann Tear Test. Often used for paper and card materials where a central cut is made and force is applied to propagate the tear and the standard is TAPPI T414 for paper. The Dauft Tear Test.

Specifically designed for geotextiles it involves a specific specimen shape and method for evaluating tear resistance and the standard is ISO 90734 for the geotextiles. Now how to calculate the tear testing? First the sample preparation. The material must be prepared according to the specific test standard being used. This often involves cutting the material into a specific shape for example, trouser, tongue or wing shape and making an initial cut or notch to initiate the tear.

Then test setup. The sample is mounted into a testing machine designed to apply a tearing force. This could be a tensile testing machine, a pendulum tear tester as in the Elmendorf method or another device appropriate to the type of tear test. Then applying the force. The machine applies a controlled force to the sample either by pulling it apart in the tensile test or impacting it in pendulum test. The force is measured using load cells or other sensors.

Then recording the force. The force required to initiate or propagate the tear is regarded. In some tests this may be the peak force reached in others it may be the force at a specific point in the tears progression. After that the calculating tear resistance or strength. The recorded force is used to calculate the tear resistance or the tear strength.

This calculation often involves dividing the force by some measure of the materials thickness width or other relevant dimensions. The specific calculations will depend on the test standard and the material being tested. Now, considering influencing factors. Various factors can influence tear test results such as the tear rate, temperature and humidity. These must be carefully controlled or accounted for in the analysis.

Now, let us look at the results. Results are typically reported in units relevant to the material and application such as Newton's or Pound's force per force and Newton per millimeter or Pound force per inch per tear strength. Example calculation for tensile tear

test. If conducting a tensile tear test and the peak force recorded is 50 Newton and the sample thickness is 0.5 millimeter the tear strength could be calculated as tear strength is equal to 50 Newton divided by 0.5 millimeter that is equal to 100 Newton per millimeter. Now, the resistance to abrasion. This test is done to measure the ability of a packaging material to withstand surface wear during rubbing and friction. The test consists of abrading the sample with the wheel of standard abrasion pad that is abrasioned for a definite number of revolutions and finding its volume loss. Volume loss is equal to weight loss divided by specific gravity.

The drop test. The test simulates actual shocks by dropping the package and its content freely against a rigid plane surface from a predetermined height. For example, a drop test can be conducted so that the package hits the surface diagonally against one corner as in the picture beside. The pack this is the package and this package is dropped by the this corner. The ISTA 1A as an international standard from for drop test. The International Safe Transit Association that is ISTA is an organization focused on the specific concerns of transport packaging.

The international standard for curtain drop test is called ISTA 1A. It specifies approved procedures for a variety of testing including vertical shock test, alternative inclined test, alternative horizontal test and of course, curtain drop tests. The drop test height is depend on the curtain weight. The weight of the curtain is used to calculate drop height from which the curtain should be dropped from. A box weighing less than 21 pounds or 10 kilograms will be dropped from a height of 30 inches or 760 millimeter whereas, a curtain weighing 100 pounds or 45 kilograms will be dropped from a height of 8 inches or 200 millimeter.

So, it is depending on the curtain weight. The curtains are dropped 10 times during the test. During the drop test the curtain is dropped 10 times on its corners, 3 of its edges and 6 of its faces during a drop test. The faces, edges and corners are identified in the diagram. These are the, these corners, this is the faces and the edges are defined in this figure.

Now, this the first table actually this is given in the English that is the FPS that the what is the package weight and how what should be the dropped weight and this is the in the matrix system that if the package weight is 1 to 9 kg then it should be dropped from the 76 centimeter. If it is package weight is 10 to 18 kg then it should be dropped from 61 centimeter. If the package weight is 19 to 27 kg then it should be dropped from 46 centimeter. If the package weight is between 28 to 45 kg then it should be dropped from 30 centimeter. If the package weight is from 46 to 68 kg then it should be dropped from 20 centimeter.

And in this figure it is given that orientation of the impacts which is in which direction it should be dropped like the face A, this is the corner the most fragile corner and if it is not known then the carton manufacturer joint should be used for this test. The B is the shortest edge radiating from that corner, this B is the shortest edge which is starting from this point and C is the medium edge which is again starting from this corner and the D is the longest edge radiating from that corner. E is the flat on one side of the smallest face, this is the smallest face that is the E and F is opposite to that E that face and G is the flat on one of the medium face, F E is the F opposite G on the medium face, G is the medium face that side corner and G and H is the again opposite to this G this H this side. And I this is the I this face is the largest face and opposite to that is J. So, these are dropped from this side

That is all for today. Thank you very much.