

Food Packaging Technology
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Lecture – 17
Testing of Packaging Materials P2

Hello everyone. Welcome to the second part of the testing of packaging materials. We are in the third module of the Food Packaging Technology course. We have already looked at the design of packaging and we have looked at the packaging testing of paper and paper boards. So today we will go on to testing of plastic films and the different tests that are done for it. I want to remind you once again of the first step that has to be done which is conditioning.

So whether it is paper or it is plastic, conditioning is important. We already said how you want to reproduce your results. Whether you test it in which season or which place, your results are going to be uniform. In conditioning, we have to remember we need to keep it at $27\pm 1^{\circ}\text{C}$ or at a relative humidity of $65\pm 2\%$ for 24 hours.

So once the paper or plastic, in this case plastic is conditioned, you can move on to the test. One of the foremost important tests just like the paper, more important for plastic is thickness. When you go and buy a plastic, you will always ask for the gauge. Gauge is the thickness. You know that the government has already reduced or it has banned.

We have the thinner gauge ones because of the environmental problems. So, the thickness of a film is actually measured in either millimeters, micrometers, microns or gauge. So, here again you use a micrometer or a screw gauge. You will find out the thickness just like you measure it for your paper and express it in this. We will move on to video on thickness of plastic materials.

Now the thickness of plastic film is another important parameter that has to be measured. Thickness is measured using a digital caliber screw gauge. As you know thickness is the perpendicular distance between two principal surfaces of the plastic film and can be directly read from the digital screw gauge. It is expressed as gauge.

0.025 mm is 100 gauge. 200 gauge is 0.05 mm. The second important test is the yield. You buy a reel of packaging material in kgs but you want to know how much of area you will get per kg.

So that is when the yield takes, comes into play. So, yield is the amount of area that is provided by a given mass. When you go to buy a reel, you will ask for 5 kgs or 10 kgs and how much area you are going to get. That is what you are going to find out from the yield of the packaging material. So, it is usually expressed as cm^2 per kg area per unit weight.

And the yield is calculated as 1000 divided by density into the thickness in cm. So, the first step is when you get your plastic material you find out the thickness using your micrometer. Once you find out your thickness you can also find out the density which I am going to explain in the next slide. And 1000 divided by density into thickness will give you the yield in cm² per kg. Density is again mass per unit volume.

Your specimen is conditioned for 24 hours but in this case to find out the correct density, you do not want any interference from air entrapped in the plastic. So, in this case when you condition, it you need to submerge it in boiling water for at least 30 minutes and this is followed by conditioning at 27°C for 24 hours. This will ensure there are no bubbles or air left inside the plastic. And then you take it for your density measurement. So, in the density measurement generally, pipet out 100 ml of dilute alcohol.

Alcohol has a density of around 0.8 g per ml. And this is kept in a Drechsel bottle and immersed in a water bath which is maintained around 27°C. Once the temperature has reached around 27°C you will take the test sample and immerse it in that by avoiding any adherence in air bubble. Keep it on your alcohol.

Then you will use the burette and slowly add water. You will add water at a rate of 0.2 ml at a time. You keep stirring till your specimen starts just suspending into your surface of the alcohol. Now this is now taken as the amount density of the solution is going to be taken as the density of your specimen.

How do you measure the density of the solution? You can take out. So, once you add the water into your alcohol you are going to increase the density. So, you are now going to find out what is the density of the mixture. To find out the density of the mixture you can use a pycnometer or a specific gravity bottle and 27°C. The density of that solution will be the density of the specimen that you have cut off.

And that density can be used again to find out the yield of the plastic. So, I hope that is clear. We will move on to another important test which is done on plastics which is done by using the universal testing machines. Here usually they do the mechanical properties of your plastics is done using the universal testing machines. It is powered by an electromechanical or a hydraulic means.

So you can, there are jaws here which helps to move. So, your plastic material that you take is cut in different strips as will be shown in the different slides. You can test the tensile strength, seal strength, bursting strength, puncture test using your universal testing machines. Again, we have discussed in the paper section how it is important to know the or how it is important to test the packaging material both in the cross direction and in the machine direction. So the direction in which the molecules are aligned or the direction in which the material actually unwinds that is your machine direction and the direction perpendicular to it is the cross direction.

So most of these tests you do both in the machine direction as well as turn it perpendicularly or in the 90 degrees and do it in the cross direction also which will give

you a fairly good idea of how the packaging is going to behave. So, the first one is the tensile strength. So, moving on to the tensile strength and the elongation and break. This is a very important test. You must have noticed that when you pull in or pull out certain plastics they do elongate.

Certain plastics elongate more than the rest of it. But when you pull to a particular force in opposite directions there is a point at which it can rupture or break. That is what exactly is known as the tensile strength. It is the force parallel to the plane of elongation or the plane of the specimen required to rupture the packaging material. So, this can happen at any point in the transit or when it is subjected to different forces.

So if your packaging material has a good tensile strength, it can withstand many hazards in the transit. So generally, they use an instrument known as tensile strength machine. You can use it in a universal testing machine also. The basic principle is the same as you can see in the video. They use the machine; they are able to maintain the grip using two jaws.

A pulling force is applied on these two ends and at a particular force it elongates. You measure the elongation that is going to happen in the plastic and at one point it ruptures. And the force that is needed to rupture it is measured as the tensile strength. Plastics they have a gauge length when you cut out the specimen. For plastics they use a gauge length of 50 plus or 1 mm length into 15 mm and width and for paper they use 180 into 1 mm length and 15 mm width.

And the transverse speed, the speed at which the machine operates are different for plastics and for paper. In plastics they use 500 mm per minute while in paper they use 150 mm per minute. Like we said this force that is also measured per unit area. So, when you take a cross sectional rectangular specimen the area of that rectangular specimen will be width into the thickness in cm. So, this tensile strength is measured in kg per cm².

Another term I told you was the elongation. The machine will measure the initial length and after the elongation they measure the length just before the breakage. So L₂ will be the final length. So L₂ minus L₁ divided by the original length into 100 will be the percentage of elongation. Naturally if you think of it the tensile strength is going to be more in the machine direction.

In the machine direction as all the molecules are aligned in particular direction elongation will be less in the machine direction. Please watch the video and I am sure you all will be able to understand from the demo how this test is done. The Universal Testing Machine or the UTM can be used for testing various parameters of a packaging material. Here we will be measuring the tensile strength of paper sample. We can determine what the breaking length is.

The tensile strength of paper is the maximum stress to break a strip of paper. Here we place the test sample between the jaws of the equipment. The speed is also very

important here. We maintain a speed of 150 mm per minute. Apply the force parallel to the direction of the specimen.

The force at which it breaks is called the tensile strength. Finally, it shows the force required to break the sample. Now we will be testing the tensile strength of plastic film using the UTM. Here we place a sample of 1.5 cm width between the two jaws maintained at a distance of 5 cm.

It is then subjected to a pulling force with a speed of 500 mm per minute. It is measured both in machine and cross direction. Now we see that it has elongated and finally breaks. The reading is directly read from the software. Another test that is important in plastic is seal strength.

We mentioned before how LDPE has got good sealing properties. Similarly, many plastics do have good sealing properties while many do not. Once you have made a seal you want to test the strength or how much force is required to break the seal. When you define seal strength you can define it as the tensile strength of the seal at ambient temperatures. It is the maximum force required to separate two layers of a seal.

The same procedure can be used in your universal testing machine. You clamp the two ends of the seal on two jaws. You apply the force in opposite direction and see at which force you can break the seal. The specimen size taken is usually all the time rectangular specimen is taken.

The width is also mentioned here. And at the breakage point you will get a curve. This curve is plotted and it is known as the seal curve. The maximum force or the tensile force that is required to break the seal is measured. And this can be observed in the video that follows. When we seal packaging materials sometimes the seal may not be proper causing the problem of leakage.

In this experiment we clamp each leg of the specimen in the testing instrument. Sealed area of the specimen should be equidistant at least 50 mm leg between the seal and the clamp. Speed of the machine is fixed at about 300 mm per minute. Align the material on the clamp and allow sufficient slack so that the seal is not stressed prior to the initiation of this test. Record the maximum stress applied to the specimen at yield of breakage.

Another test that can be done in the universal testing machine other than your tensile and seal strength is the tear strength. Suppose there is a notch or a tear already produced. How much force is required to continue the tear along the specimen? That is the tear strength. Here is the inner tear strength. So, when you cut it and attach it to one end to each of the jaws it looks like a trouser.

So this is also known as a trouser test. So straight cut is introduced in the rectangular sample parallel to the long edge. It is mounted on the jaws. One leg is clamped to the lower jaw and one to the other jaw. That is why I said it looks like a trouser. And the force that you require to break it or tear it along that edge is known as a tear strength.

This also can be observed in the video that follows. Next is the test to measure internal tearing strength. We take a rectangular test specimen having a longitudinal slit extending over half of its length. This is now in the form of a trouser leg formed by the slit. Average force required to tear the specimen completely along its length is calculated as the tear resistance of the packaging material.

Set the initial separation around 7.5 cm and carefully clamp it. The speed of the testing machine is set at 250 mm per minute. Start the machine and when it breaks the force is noted which is the tearing strength. The results are obtained in the software loaded in the laptop. We will measure the force and divide by the thickness in mm to get the internal tear resistance of the packaging film.

Now just like in your paper puncture resistance is another important test for plastics too. When you have a blunt object punching your product at a particular force it might puncture the plastic. Universal testing machine will apply a force to the specimen and it creates a pressure or and creates a puncture. So, this puncture resistance test you can either change the force that you apply and you will also measure the distance through which the probe will pass through. So, both of these will measure the resistance or the strength of the packaging machine.

Usually the puncture speed is around 0.001 inches per minute to 40 inches per minute. So, if you have a greater puncture resistance it is better for your plastics especially on transit. We are now going to do the puncture resistance of the test packaging material. Puncture resistance test is performed to determine the ability of the material to withstand puncture. You can see that the specimen is cut and kept between opposite phases of flat material having concentric rings.

The thickness of the specimen should be measured earlier before we start the experiment. One of the plates has a circular opening of about 6 mm in diameter and allows the passage of the stainless-steel needle. The lower plate will have an opening of 25 mm diameter and will provide a fixed free area where the specimen can elongate while subject to the pressure of the needle point. This stainless-steel needle has a diameter of 5 mm and is machined at one end to produce a taper with an incline angle of 12 degrees with a tip of radius of around 0.

8 mm. The needle should be positioned perpendicular to the specimen. When it moves it punctures the specimen. The trapezium software is used to measure the puncture resistance by measuring the puncture force in Newton. Divide this value of force with the thickness to get Newtons per meter.

Last one is the bond strength. Now especially that is important for plastics which are laminated. Now if you recall, lamination is when two or three different packaging materials are bonded together by adhesives and brought together so that the final packaging material will get the advantage of each of these different packages. Suppose you want to see that these are kept together throughout the storage life of the product.

So, you want to find out the stickiness or the tackiness or the bond strength of the flexible packaging material. And to measure this, what they do is, there are two ends of the specimen, it is clamped to the jaws and slowly the jaws move apart.

So each of these different packaging materials can be separated and you want to see how firmly it stays together. The test speed is around 300 mm per minute and you record the force in grams per 50 m. So, your bond strength is expressed as grams per 50 mm width and it is calculated from the graph. So, with that we have gone through the different tests that are done on plastic packaging materials. So, there were a number of tests that were done, especially thickness.

You need to go in for your other tests like your tear strength, tensile strength, bond strength, seal strength, which are all very important. So, these are much clearer to you I think by now. And in the next class we will continue with this packaging testing in plastics but in different properties, especially your barrier properties.

That will be discussed in the next class. Hope to see you then. Thank you so much