Food Packaging Technology

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Week – 04
Lecture – 16
Testing of packaging material P1

Hello everyone. Welcome to another session in the Food Packaging Technology course. We are now in week 4, module 3. After discussing the designing of the packaging materials, we are entering into another important topic which is the testing of the packaging materials. We will be discussing this in 3 or 4 parts because it is a longer portion and we will also be showing videos which will help you to understand these different tests a little better. Now testing of packaging material is an important step in the whole process.

It helps to check the existing quality. You make a packaging material and you would like to see what is the quality. Does it withstand? You would like to see if it confirms to all the standards that are there. Another thing is that you can make a judgment of any shortcomings and you can change the design or may take appropriate measures for that.

And more important, you can check it and compare it with the competitive materials that are in the market. So, these qualitative tests that we do are divided into physical, chemical or mechanical tests. Now, we all know and you have already studied that there are basically 4 types of packaging materials. One is paper or the paper board, plastics, metals and glass. Now in these sections we will not be dealing with the glass and the metal testing, only with the paper and the plastic testing.

Now when you test the packaging materials, the first thing that you do is something called conditioning. I will explain this also in the next step but whether it is paper or it is plastic, the first thing that you would do is conditioning the plastic or the paper. And the different tests that comes under paper is grammage, which is the weight of the paper or paper board, thickness, COBB's test or the water absorption of the paper. We will also test tear resistance, puncture resistance and bursting strength. So, you will get a fairly good idea post the tests that are done for paper and paper boards.

Now going to plastics, plastic films we are looking for the thickness of the plastics which is a very important criterion. Another is yield and density, dart impact,

tensile strength, seal strength, trouser tear, puncture test and the bond strength. Now other than these kind of mechanical, these are mainly your mechanical tests that you do on the plastic films. We also test for its barrier properties and in that we check for WVTR which stands for water vapor transmission rate, GTR which is gas transmission rate and the overall migration. So don't worry we will be going in details in the coming slides.

And in my last part of testing we will go into how to identify different plastics. You have umpteen number of plastics in the market, how do you identify what kind of plastics are there. We will also touch upon accelerated shelf life or the storage life of the products that are kept in the different packaging materials. So, let's start with the sampling plan. Whether you do it in the product or the packaging material, the first thing is always you need to have a sampling plan.

A set of samples is actually the total number of samples that are taken from a whole batch of material. So, you might have a whole web of paper or paper board, corrugated fiber board, the rolls of plastics. So, from that the number of samples that you take is very important. Sampling plan is the first thing that we need to take care of. And the second most important step like we said is conditioning.

Materials like paper are very hygroscopic. Hygroscopic means they absorb the water from the atmosphere. So that actually affects the repeatability of the test. So, if you want to ensure the repeatability and reproducibility, a standard procedure has to be done. And that is when we expose a test sample, whether it's paper or it's plastic, we expose it to a standard condition.

And that is known as conditioning. Generally, we have a humidifying chamber where it is kept at 27°C ± 1, 65 ± 2% relative humidity. So, if you keep it at this temperature and relative humidity for 24 hours, whether you do it in Kerala or in Rajasthan or in Kashmir, you are ensured of the reproducibility of the results that you're getting. Okay, that is the first step of testing. So, let's move on and see a video of this in the laboratory.

The packaging industry uses different materials as craft paper, paper boards, plastics and laminates which must undergo different tests for quality to check for any change from batch to batch. Corrugated fibre boards are made up of craft papers. Normally three different ply boards are used, 5 ply, 3 ply and 2 ply. In a 3-ply corrugated board, you will have only one corrugated media and two liners. What you see here is a delaminated 5 ply corrugated board where we have three liners and two corrugated media.

In the manufacture of corrugated fibre board, we use craft paper which is a brown paper and the quality of the paper is very important. So, when we do the quality assurance of paper, we should first condition the sample. All tests should be done only on conditioned samples, whether paper or plastics. This is a humidity chamber or a conditioning chamber where conditioning is done at 67% relative humidity at 27 degrees centigrade for at least 24 hours to bring the moisture level to 8 to 10%. Saturated sodium nitrite in a desiccator can also give 64% relative humidity.

Conditioning ensures that the results are similar or consistent when done anytime or anywhere in the world. Okay, so once you have conditioned your paper and plastic, I am going to go in for all the tests that are done for paper and paper boards. The first and most important is the grammage. The grammage simply means the weight per unit area. It's the mass of the paper or paper board per unit area and it's expressed as GSM.

GSM stands for grams per square meter. So, this test is explained in our IS standards, part 1 (1987). So, what you do is you cut your samples generally in a size of 10 by 10. There are standard templates by which you can cut up a specified size and you take the weight in the standard weighing balance. At least you need to repeat it 10 times and take an average of these values.

And it is expressed as grams per square meter. Now if you do have an equipment called a substance indicator machine, you can directly add sample into your substance indicator machine and get the readings as GSM. So now you have a fairly good idea of how to find out the grammage both with the equipment and in the weighing machine. Once you take your weight in the weighing machine, what you get is in the 10 by 10 size. That area 10 by 10 is 100 square centimeters.

Now you want to express it as 1 meter square. So, 1 meter square is actually 1 meter by 1 meter which is 100 centimeters by 100 centimeters which is 10,000 centimeters square. So whatever weight you get in your weighing balance is actually in only 100 centimeters square. So that weight multiplied by 100 will give you the weight per meter square.

I hope it is clear. Another thing you must have seen the corrugated fiber boards also. The corrugated fiber boards before we do our test we need to delaminate them. These are also shown in the video where each of these is soaked in water for a few hours or few minutes also till you can find out that you can delaminate or you can separate out each layer one by one. So once this is done, the corrugated medium, you have a liner and you have a corrugated medium. The corrugated medium has to be ironed and then each

of these layers have to be weighed separately and added together to get the weight of the fiber board.

So, when you look at this picture here, the graphic representation, you do have a liner which is that straight portion and you have these corrugated portions. These are known as flutes. This is the corrugated medium and this is your liner again. So, we have this 3-ply cardboard, we have 5 ply, 7 ply. This will be a 3-ply fiber board.

In a 3-ply fiber board, you have 2 liners and 1 corrugated medium. In a 5 ply, you will have 3 liners and 2 corrugated mediums. So, I hope that is clear. Now depending on the size or the height of the flute, this is the flute, the corrugations, the height from this portion to this portion which is represented as t_f.

This t_f is $t_c + t_m$. This height of the flute and the wavelength, that is the distance between 2 troughs or 2 crests, depending on that you can divide your cardboard boxes into type A flute, type C, type B and type E. These are the different heights and the wavelengths that you get. These are representations of how you can combine B-C flute, B-C-E flute, E-B flute, E-C-E flute. So, when you do a testing, grammage of one of these corrugated fiber boards, first be sure that you delaminate it, take the different layers and weigh them separately. After conditioning the paper sample, we can check for its grammage in a substance indicator machine.

We have different templates to cut the paper into the desired area. 10 by 10 cm, 10 by 20 cm or 20 by 25 cm. Here we are cutting the sample using a 10 by 10 cm template which is 100 cm square. Switch on the machine, choose the template option and tear the machine to zero. We can directly insert the sample or read the grammage or the weight per unit area of the packaging material as g per square meter or gsm.

In the case of paper boards, the first step is to delaminate the different layers by immersing in water till the layers separate. These are then separated and ironed to dry. The grammage of each layer is then determined and added together to get the gem of the corrugated fiber board. Other than using the substance tester, we can directly weigh a known dimension of sample in an analytical balance to find its grammage as g per square meter. Moving on to another very important test which is the thickness of the paper board.

Thickness as you know is actually the perpendicular distance between two parallel surfaces and this is important because based on the thickness you can say if it is the stronger material. Usually, they use a micrometer screw gauge. This is automated or the manual one. So, in this test you take the values directly from your screw gauge and

the minimum, maximum and the average values are reported. You do a number of tests, you do at least 10 readings and take an average of these.

And these are expressed either in millimeter or in mil s. So, if you look at this table here, these are all units for thickness. 100 gauge is 25 microns. And 1 mil is equivalent to 1 by 1000 of an inch. So, you can convert it accordingly and express your values in any of these units.

This is a pictographic representation of a screw gauge. You have the pitch scale and you have the thimble scale. Now one important thing is the least count which is the term that comes in the screw gauge. So, this is a measure of the instruments, the smallest reading that the instrument can take or it is actually the precision of the instrument. So, for example, this is your scale which is mentioned as the vernier graduations and you have the thimble scale.

Suppose a pitch scale, the least one is 1 millimeter and the number of graduations that you have on your thimble scale is 50, then least count will be 1 divided by 50 which is 0.02. So, this has to be coming in the calculation when you do the thickness of the material. We discussed gramage and thickness and we are going to move on to the COBBs or the water absorption. Now paper and paper board COBB's test is a very important test.

Especially during transit, it might encounter water sprays or water puddles. So, you are not sure how much water the cardboard box is actually going to absorb. That is eventually going to affect the product itself. So, your COBB's test or your water absorption test, it gives an indication of the resistance to water absorption by the packaging material. So, the amount of quantity of water that is absorbed by a specified area of the paper surface is going to be measured and it is going to be done in two different times.

You need more time to be taken for your cardboard boxes because it is thicker. You go in for a 30-minute COBB's test. While for a normal craft paper or thinner ones, you can go in for a 1-minute test. So, in this, again you can look at the video. The video will clearly demonstrate the different steps that are done in the COBs test.

But here you use a water absorption apparatus basically. And this device will allow you to uniformly wet the specimen in one side. You allow the package to soak in that. You take a specified area of the package, generally circular.

Diameter has to be mentioned. So, once you know the diameter, you will know

the radius. will give you the radius of that circle. And that area is taken and you soak it in the water. So, this water time I told you for normal papers, you can use 1 minute. For the corrugated fiber boards, you will go in for a 30-minute test.

So after it is done, once you have placed it and kept it for the first time, you take out the paper board and you will remove the just the absorbed water, the top portion water. So, after your time period, you will decant the water and you will quickly blot out the water that is there on the surface and then take the weight again. The weight is taken before the test and weight is taken after the test. And the increase in weight will actually give you per unit area. The increase in weight per unit area will give you the grams per square meter of water that has been absorbed.

Okay. Next is the COBB's test to determine the waterproofness of the paper-based packaging material or the amount of water that is absorbed per meter square. A known area of the paper or the board is cut and the initial weight is taken. It is then inserted in the COBB's apparatus between the cylinder and the rubber diaphragm and made airtight. Now tilt and invert the apparatus and add the water. Paper is exposed for 1 minute and paper boards are exposed for 30 minutes.

After the required time has elapsed, decant the water and remove the adhered water or the surface water with the help of blotting paper. Then weigh the sample. The increase in weight gives the COBS value in grams per meter square. So, we went through 3 tests.

Grammage, thickness, the third one is water absorption. How much water is being absorbed by unit area of the paper or paper board in a specified time. And the fourth test is your tear resistance. Now tearing can happen anytime, either during shipment, during handling, it can come across a sharp object which can tear it. So, your paper board has to be resistant to this tear.

So generally, we do the test in the laboratory. We actually initiate the tear in the beginning. Now there is one important concept here, whether it's paper or whether it's plastic. It has two directions. One is the machine direction and one is the cross direction. As you see here, machine direction is the direction that the material will unwind.

So, most of the particles that are there in the packaging material will be arranged in that direction, that is the machine direction. And the direction that is perpendicular to this is known as the cross direction. So, in the picture it must be clear that the direction in which the paper unwinds or the reel unwinds, that is the machine direction generally, and the other one is the transverse direction or the cross direction. So, if you tear a paper, naturally it will tear more easier in the machine direction rather than in the cross

direction. Because all the molecules are arranged in that direction, it's easier to tear along that line.

So, when you do your tear test, it is important to do your tear test both in the machine direction and the cross direction. Now there is another interesting thing that it's not every time easier to find out which is the machine direction and which is the cross direction. So, you will do it in both directions. That is also clear in the video.

Once you see the demo, it will be clearer. So tearing strength actually gives you the resistance of the paper to wear and tear. And the test machine, the apparatus that you use for this is called a tearing strength tester. So, you clamp the tester, it is in the tester, and 25% of the specimen is torn initially. You initiate a tear and then you allow the pendulum to be released. Once the pendulum is released, the rest of the 75% of the paper is torn and you will find out the force, it's expressed in gram force, the force that is required to tear the paper.

Paper that is going to be resistant will have more tear strength or more force will be required to tear it. While a paper that is easily torn will need less force to tear it. So, there are three scales in the apparatus if you have noticed in the video. So those paper materials that you have within 100 gsm, grams per square meter, you will read scale A. Those that are between 100 to 200 gsm, you read in scale B and those which are between 200 to 400 gsm, you read in scale C.

So, we have completed four tears which I hope are clear. The test for measuring tear strength of craft paper checks the resistance of the packaging material to tearing that might occur during operation. For this, take the condition paper and cut it using the standard template. All in one layer is then inserted into the tearing strength tester. It is tested both along the machine direction and cross direction. Once inserted, release the pendulum and directly read the tear strength from the scale in gram force.

Divide the reading by the number of layers to get the value for one sample. Within 100 gsm, read the scale A between 100 to 200 gsm, scale B and 200 to 400 gsm, scale C. The fifth one is the puncture resistant tear. So, it is just similar to your tear strength.

Your puncture resistance is also very important. You do not know if you will encounter a sharp object during the transit. So, the paper, the paper board in fact, has to withstand this puncture. And it is an indication of the paper components or the container components to resist damage if it encounters such sharp objects in it transmit. And the equipment that you use is called a puncture resistant tester.

So, this is again shown in the video. You clamp it in the jaw and as you replace it in the machine, release the pendulum and the pendulum will puncture it. The puncture test actually measures the force again to puncture it or create a tear in it. And you can read it directly from the scale and it is expressed as beach units. Now the puncture resistance of the packaging material is done using the puncture resistance tester.

The energy to puncture materials is measured as beach units or kg cm. We have different weights which must be entered into the machine before starting the test. The sample is inserted and the pendulum is released to puncture the materials. Its resistance to puncture is directly read in kg cm. So now that you have observed the video on puncture testing, we will move on to bursting strength.

This is another test that is important for your paper boards. Especially during transit when you have a pressure applied on the boards at any particular point, there is a chance for it to burst or leave a tear in it. So that is usually measured by a bursting strength tester. Here you will measure the hydrostatic pressure in kg per cm2 or p.

n.2 that is needed to burst your material. Whatever paper you have, you will cut it usually in the size of 12 cm by 12 cm and condition it properly and then you will apply hydrostatic pressure from one end. The instrument once it applies this pressure, the pressure is increased till it ruptures and they will record the maximum pressure that was required to break it or burst that package. You need to make around 10 tests and take an average. So, most of these tests, be very careful that you take at least 10 tests and take an average of it because it might differ at the different specimens that you take.

The points that you take the sample, that also has an effect on the final result. So, make sure that you take at least 10 tests and take an average of these. And the report is made in either pounds per square inch or kg per cm2. This is a digital bursting strength tester. Bursting strength is the measure of the ability of the packaging material to withstand hydrostatic pressure in kg per cm^2.

It is widely used as a measure of the resistance to rupture. In many kinds of paper, it gives an indication of the tensile strength as well as the stretch of the paper. Here we first insert the sample into the slot and apply hydrostatic pressure. There is also a piston that pushes the sample and causes hydrostatic pressure and it will finally burst. The bursting strength is then recorded in kg per cm2. I hope you got a very good idea of the different tests that you do for paper and paper boards.

The next session we will be dealing with some of the tests that are going to be done on plastics. These tests are very important like I said, not only for the quality control but

also to see if you need to make any change in the design or in the cushioning so that your contents are safe till, they reach the consumer. We will see you in the next class. Thank you so much.