Lighter-Than-Air Systems
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Lecture - 65
Fabric Testing Machines – Part II

I will show you one more application where we want to use this particular system and that is this tester. Now permeability as you know is one very important requirement. So, air permeability now to the best of my knowledge there is no machine available commercially for helium permeability of a fabric because that is a very specialized niche area. Machines are made by people for common applications where there is a demand.

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Now air permeability is a very important requirement. Automobiles, they make these airbags. They have to be air permeable or nonpermeable. Similarly, there are many fabrics which have to be nonpermeable. So, there are testing machines available in the market for air permeability. This is one such machine which we bought for around rupees 70,000. What is happening here is you can see these two plates here, actually they are not plates.

They are two elements. So, you put a fabric piece in between these. There is a small circular place where you can keep the patch and then you bring the jaws together and then you tighten it on the top like this so you create a very tight barrier. And then we can connect this system here to air compressor and this particular system it uses. Now another question I will ask you just to see how innovatively you can think.

The air is leaking from this fabric, but the leak rate is very less. Now, I would like to sense at what rate the air is leaking. So what I will do is I will put the fabric between the jaw, I connect it to a compressor and leave it for 8 hours. Now under the pressure of that and you can regulate the pressure, there is a pressure control facility here. This dial that you see here is basically for pressure control what ΔP you want to create. So, I create ΔP.

In real life for the airship the ΔP is very small. Therefore, the air will not leak very rapidly. So, maybe it will be a 3 cc in 8 hours, very small amount. How do you measure or how would you measure air leakage of 3 cc in 1 hour? What kind of a sensor will you attach to this particular system? So, on one side there is pressure, on this side there is vacuum or ambient air and now under pressure air has come but the air which is coming only 3 cc or 5 cc or 10 cc in 8 hours.

How do I measure? You cannot put any device which like a rotameter or something that will work for very high flows. The flow rate is very low. So this air will not push any big object or a needle or any spring to create pressure to show you the reading. Think about it.
“Professor – student conversation starts.” Yes. Vacuum, then we can try like spark corresponding. What do you think is the spark?

If there is a spark we can sense that there is any oxygen or something in between it so that there is inonization of gas. No the amount of air is so less and see it is not necessarily vacuum. Basically both sides have air only. Both sides have air chamber, but in one side the air is 3 cc more after 8 hours. There is not actually a vacuum, so I am wrong, it is not a vacuum. Think of some way of measuring 3 cc or 4 cc or 10 cc air leakage over 8 hours.

Increasing weight of 3 cc air. There will be cooled air weigh it. Very difficult. Then the cost of the balance or the weighing machine will be 10 times the cost of the equipment. A weighing machine which can weigh a difference of 3 cc weight of air very difficult. Again this is very simple. It is very simple, when you hear it you will laugh. Sir we test the excess air over the inverted testing of water and water has been displaced. You can do that. So, what you can do is you can connect.

But how much water will 3 cc of air push? Water is 1000 times heavier than air. So, 3 cc of air will not come out. The pressure which the water will exert back. See for water to move the pressure should be more than the weight. We will not push the water, it only displaces. It will not displace. If water comes then only displace. If water is… But the force created by 3 cc air on a column of water is very less. So, with that force you cannot overcome the inertia.

See if there was water inside and you can say there is a 3 cc of water that will push it up and you make a very thin capillary refill you can measure it, but now you are trying to push a column of water with air. The air will bubble through that. If the air bubbles through how do I measure the rate? It goes… So, how do I measure? See if you have water, so air has come out, it has bubbled through and gone on the top, how much air has gone?

Assess with a caliberator height of water and displacement. That is what I am saying the height of water displaced will be very small by 3 cc or 10 cc of air. If I have a gas there, let us say a colored gas air will mix with it. If you say I will have a column of gas with a partition and now 3 cc of air has come that it will push it up this could be possible. Think of something else.

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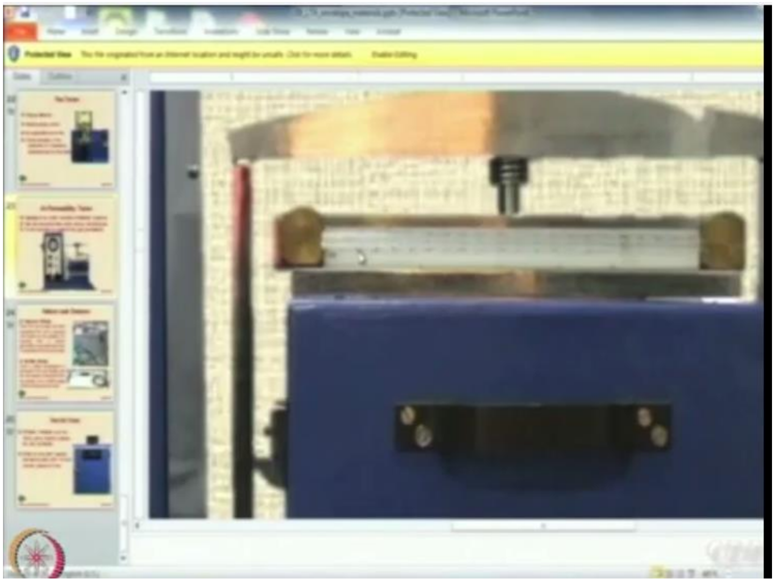

So, I will tell you what they do. If I zoom it, you will probably see it. So, if you see on top of this there is a capillary tube. This capillary tube is connected to the outlet of the upper chamber, the chamber which is away from the fabric collector chamber. And what we do is this capillary tube has a column of filling water and inside that column of water we insert an air bubble.

So, they have given a very small device by which you can actually create a small air bubble and this air bubble, it is not very clear but I can show you if I zoom further. There is an air bubble, somewhere here you can see there is some mark, is it visible to you or not? There is some darkish mark here that is the air bubble. So, this air bubble is created somewhere at the beginning and there is a recording.

And then over a period of 8 hours when the air comes out, now air will push against air so it will move it and then they are calibrated this tube by leak rate of air. So within the range of expected leak rates of the gas for 8 hours or whatever duration, they have made this tool large enough. So I will encourage all of you to come to the lab and have a look and maybe do a small experiment on how these systems work.

So now, this is for air permeability but we do not work with air inside the balloon except for testing purposes. So to characterize the fabric against helium or hydrogen what we need to do is two things, simple things. On the inside or on the intake side, I can connect a cylinder of gas under pressure. A typical gas cylinder hydrogen helium is 140 bar pressure inside. So, if I open it, it will come out at a very high speed.

So, much high speed that if you put a small PVC nozzle, that nozzle can become ice cold within 15-30 seconds that is the speed at which helium comes out or hydrogen comes out. So, you connect this to the cylinder and you knock off this permeability**,** this particular sensor and connect the helium leak detector. And when the gas comes out that detector is very precise it can measure. So, this is one project which I want some student to do.

This could be a good project for any student who wants to work on a practical fabrication. Just connect the cylinder and device a connector for the HLD. So, this is to be modified for determining. One student actually came and tried attempted doing it, but he could not get much ideas. So, he ended up just testing this for some information.

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Then one another issue. It may not be useful for us that much because we use envelope at low pressure. But, in our systems can you envisage a situation at which the ΔP increases, increases, increases and becomes unbearable. In an LTA system, normally the pressure inside is not very large, but can there be a situation? So suppose there is a balloon which is cut and it starts going up ΔP keeps increasing because P outside keeps falling.

A time will come and the fabric will tear. So, this particular system is a digital bursting strength tester. So, what you do in this case you in this particular area below this, you just put a small piece of fabric of a particular shape and it increases the pressure till there is a hole created and it tells you what is the reading. So, you come to know that this fabric can withstand ΔP at so much. Therefore, we can work out at what height this balloon will tear. So for that purpose, we can use this equipment.

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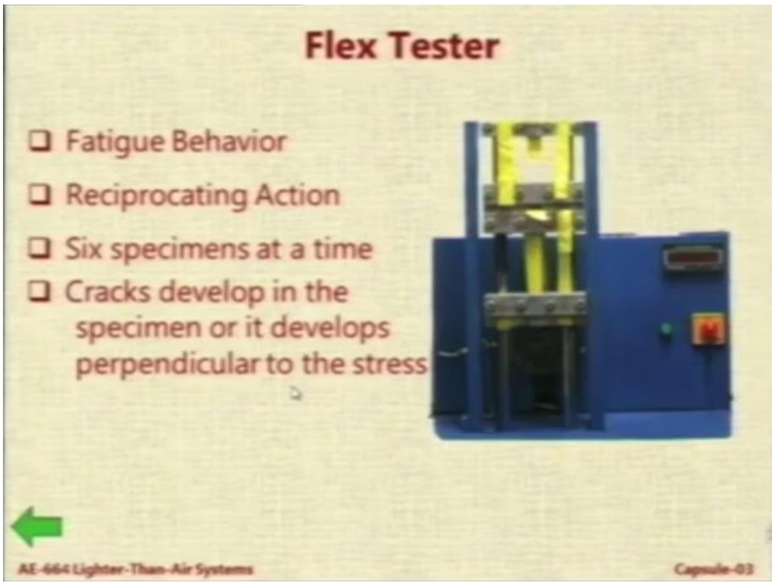

Then we have a flex tester. A typical LTA envelope will go up, deploy for some time, come down, again go up, again come down. Maybe to take care of the winds, you may lower it, raise it, lower it, raise it, it will undergo fluxur because delta P will keep changing. So there are some flex testers available which tests the fatigue behavior of fabric. So what you do is you basically just attach strips and they just keep moving like this.

And it tells you after how many such oscillations the envelope starts developing permanent strain. So, this machine can test 6 specimens at a time. You put all 6 specimens in the jaws hold it and put the machine on, it just starts moving like this and it just tells you. So, you will see when you test it there are cracks developing and these cracks slowly propagate and then it breaks.

And then it just stops in tells you that this particular fabric can withstand so many cycles. I will know that if I make an aerostat with this material, I can permit 6 deployments. In the seventh deployment, there is a chance that there will be some cracks provided the pressure difference is matching with the load coming.

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Now, another area which is important is flame propagation. We saw in Hindenburg that when the flame started in the front, very quickly it came to the rear. So, for that we have purchased one instrument called as a Flammability tester. So, what is done in this system is that you have a standard LPG or a small LPG cylinder and there is a small equipment here, a small pin here where a flame can be developed. And then there is an inclined scale.

I will try to make it a little bit larger you can see this.

(Video Starts: 14:33) So, you see this particular thing is the flame holder. At this point the flame is created. It is nothing but a small syringe through which the LPG comes out and you just put a match there and the LPG catches fire so there will be a flame. And then there is this inclined system on which you mount the fabric.

And on top of the fabric what you do is you have this simple thread and this thread is connected to the fabric at a point near which the flame will be created or actually you put it across this length in the top. What happens is that when you ignite the clock starts and then the flame travels. When the flame reaches the thread, the thread burns. When the thread burns then this particular system drops. So, this weight it drops and it detects.

So, the time between the flame propagation to the tester dropping is measured. So, you know that flame will spread at this rate in this fabric. Some fabrics are a very good, the flame does not spread or it spreads at a very low rate, in some cases it spreads very fast. So, the post ignition behavior of fabric can be tested. Interestingly, none of these equipments are actually designed for LTA systems.

They were designed for commercial fabrics and other things.**(Video Ends: 16:31)**
but we have procured them basically for trying to adapt them. So, this is the basic system.

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And then we have also hot air oven. So if we want to make a pizza in the lab, we have an oven, we can easily use it. This can go up to 250 degree centigrade enough to bake a nice pizza. So students have never tried it, I do not know why. I would have done it if I was a student in this lab. So what we do here is subject the material to high temperatures and then do the testing to find out what is the effect of exposure to temperature on the properties.

And if you want to create the sector long term aging and you want to accelerate that you can do it by subjecting it to temperature. It is very accurate, up to 1 degree accuracy, you can create temperature.

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Sr. No.	Fabric	Material Density (gsm)	Thickness (mm)
1	Metallized Polymer	65	0.068
2	PVC coated Nylon	168	0.125
3	PU coated Nylon (Red)	40	0.062
4	PU coated Nylon (White)	43	0.049
5	PVC	215	0.146
6	Nano-clay Coated polyester	35	0.030

These are some of the fabrics which have been tested by our students in the lab. I have taken this photograph from a paper which they presented recently in IIT Madras. There was a paper on material science and technology. So, you can see that we have material available from 35 GSM to 215 GSM in the lab. And we have also measured the thickness. We have a very nice thickness gauge also.

So there is a nano clay coated polyester, which is used by us to make very small airships that are the Flying Fish. Did I show you the flying fish? I will show it to you sometime. Then we have red color PU coated nylon, nylon having with PU coating. And then so you can see it is 40-43 GSM. Slightly more than this one, but it has got much better strength.

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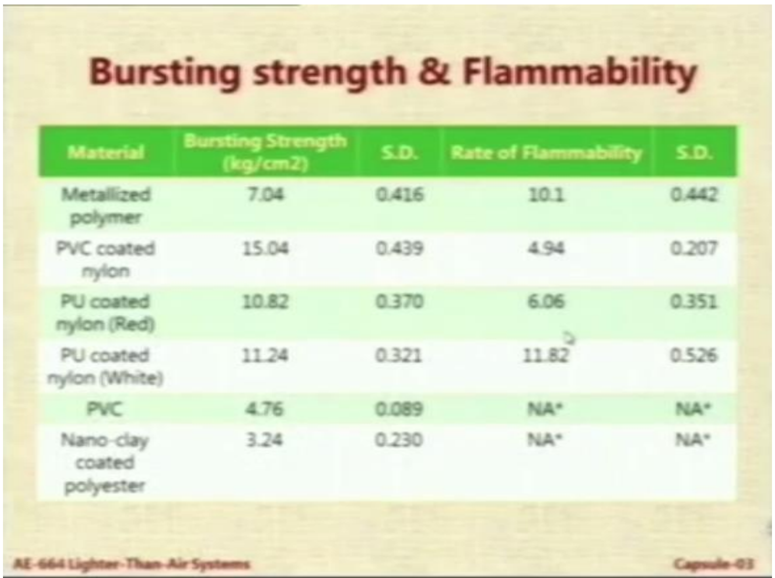

Material	Bursting Strength (kg/cm2)	S.D.	Rate of Flammability	S.D.
Metallized polymer	7.04	0.416	10.1	0.442
PVC coated nylon	15.04	0.439	4.94	0.207
PU coated nylon (Red)	10.82	0.370	6.06	0.351
PU coated nylon (White)	11.24	0.321	11.82	0.526
PVC	4.76	0.089	NA*	NA*
Nano-clay coated polyester	3.24	0.230	NA*	NA*

Then we did the bursting strength and flammability characteristics. So you can see for PVC or nano clay, there is no value because it just burns immediately. But other fabrics you can see that the flame rates are different.

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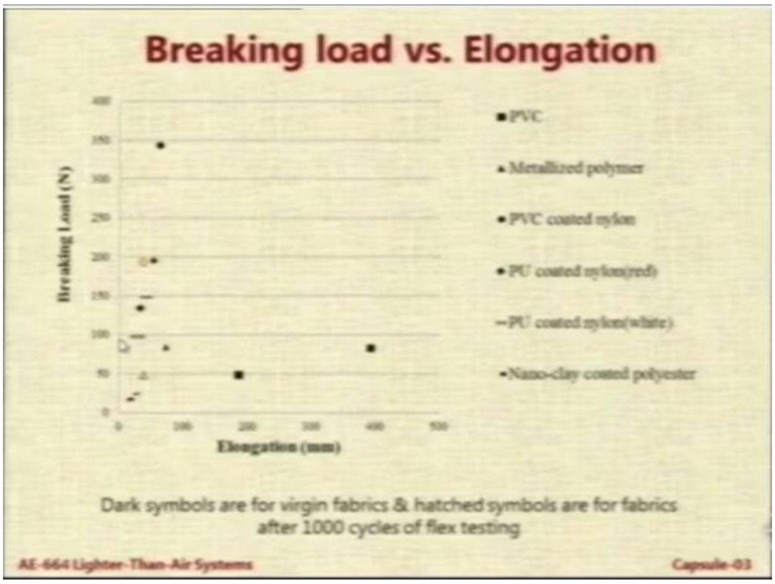

And then we did some testing on the breaking load versus elongation. So some materials have got a very strong breaking load, but elongation is very less. And some they have a very low load but it elongates a lot. So PVC stretches very easily but does not break. It breaks only I mean 100 Newtons 10 kg is enough to start stretching PVC, but it elongates a lot, right. So on that note, we can stop for today.