Lighter-Than-Air Systems
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Lecture - 61
Envelope Materials – Part I

So, we have been looking at static lift generation and we have been looking at its variation with various parameters. So, there is one section still remaining from that portion which is basically the calculation of the parameters with change in altitude and also pressure altitude. But I thought it was becoming too numerical, so I wanted to take a break.

Therefore, today we will take up a topic which is supposed to be have taken next time, but I am just switching it just to allow a little bit of variety. So, today we look at the properties of material of the envelope. So, as you all know envelope is the most important component of an LTA system and therefore it is very important for us to understand its properties.

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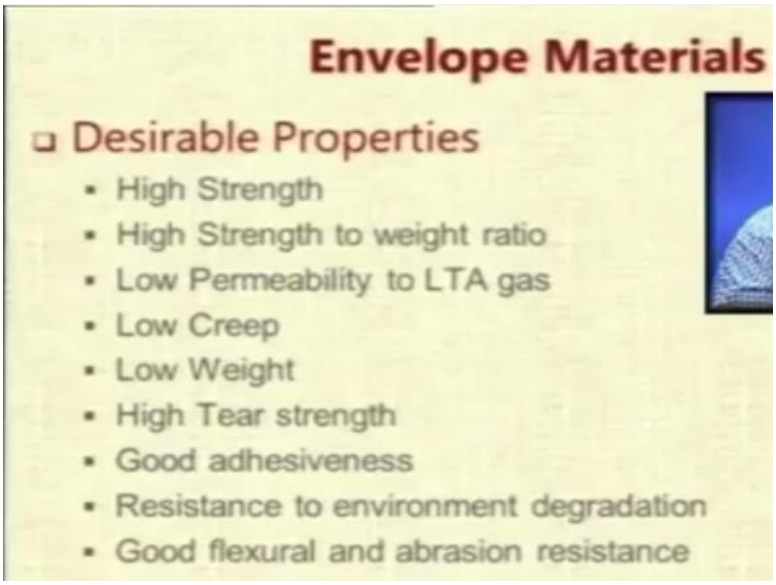

Now, some properties of an envelope are desirable because they help in the system meeting its prefers requirements. Not in order of any specific preference, I would like to list down the various properties which are desirable in the material of an LTA envelope high strength because especially in a non-rigid airship, which is the most common airship being used now-a-days, the entire load coming on the envelope is taken by the envelope itself.

There is no internal structure. So, all the shear loading which will come on the envelope everything has to be sustained by the material itself and hence high strength is important, but this strength is measured in a very interesting fashion. There are two directions of a fabric. There is a warp direction and then there is a weft direction, we will see that in more detail. So, strength is determined in both directions and it need not be the same.

So, one should keep in mind that in general the LTA materials are anisotropic, they are not isotropic. In fact they are isotropic, they will have material properties different in different directions. Secondly is we would like this material to be able to take the load, but at the least possible self weight because the self weight is going to deduct from the gross lift to give us the net lift. So, therefore if there is a fabric which is very good in taking the load, but if it is very heavy, then it is of not much used in LTA systems.

So, the challenge is to make it load carrying, but with low self weight. A major task of the envelope is to contain the lighter than air gas inside. So permeability of gas is very important. Permeability is needed to be good for either hydrogen or helium or both depending on which gas is planned to be used. So for passenger carrying airships, we know that as per the legal requirements we cannot use hydrogen. So the next best gas is helium.

So, in those cases helium permeability is the prime requirement. But in remotely controlled airships or in unmanned aerostats, aerostats are mostly unmanned, there you might deploy them with hydrogen or helium depending on the application. So you need to have good permeability for both these gases. The next required property is creep. The creep resistance should be high and it should be able to withstand creep.

Now what is meant by creep? Can somebody help me? Does anybody have any definition for creep? Have you heard about creep in metals? See change in the length of the specimen upon the relative length is the strain. Yes exactly. It is the failure of a material due to prolonged exposure to loading. So in an LTA system, you deploy it for weeks or months. So it might be possible that there is a fabric which can take a lot of load, but only for a small amount of time.

When the same material is exposed to one month of loading maybe it is start deforming faster. So, this is creep and definitely we want a material to have very low creep propagation or very high creep resistance. Obviously, high strength to weight ratio and low rate are relative to each

other in some ways, but low weight is a direct parameter. So, obviously a fabric of low weight has no use if it does not meet the requirements that does not contain the gas if it cannot take the load.

But given a condition low weight is another requirement. High tear strength is also important because this system can be subjected to some amount of local loading because of which it might tear and when it tears the speed at which the tear propagates is going to be the time available between an incident and a disaster. So, many times like in parachutes for example, we use nylon fabric for all these properties and we have one called the ripstop nylon.

So, there are woven structures you can say square fabrics which are enclosed. So, the tearing will start at some place and it will end at the nearest rip cord and it will not easily propagate further. So, similarly it is important that the fabric that we use should not have very easy propensity to tear after the load is applied. So, for that special testing is used in LTA fabrics to determine the tear strength.

Another property is good adhesiveness. In modern fabrics the method of joining the envelope material happens to be adhesives. The Japanese have made tremendous progress in this area and they have come up with special silicon adhesives which are extremely good, extremely long lasting and they give very good strength, but certain materials may not be easy to join by adhesives.

So, if we are going to use adhesives and which is going to be the case in most of the applications in the future at least, it is important that the nature of the fabric should be such that it allows it to be stuck to other fabrics. When you expose an LTA system for a long time in the atmosphere, there will be ultraviolet radiation of the ambient from the sun and the fabric will break down over a period of time.

So, therefore either we have to provide coating on top of the envelope to have very good ultraviolet resistivity or the fabric itself consists of materials which have inherently high resistance to ultraviolet degradation. So, environmental degradation could also come because of water, it can come because of snow. So the fabric should be such, so many materials are available which meet our requirements, but they fail at this requirement.

Similarly, there are many materials which are extremely good in other things, but they fail in adhesiveness. It should have a good flexural and abrasion resistance. This system might rub against some obstacles, for example if you deploy an aerostat you might have a situation where it might start rubbing against some trees or some other manmade or natural objects. When you bring the aerostat down, there might be some kind of rubbing between the envelope and some components of the winching and the mooring system.

So if it does not have good wear resistance, it will tear or it will create damage at that point. So it is important that the surface of the fabric should be able to take a little bit of beating. Then you will be surprised to know that even in ambient air, sometimes we have a lot of particles which are suspended and these particles can start rubbing against the envelope and cause abrasion. So it should have good abrasion resistance.

Flexural resistance is required because we may have to bring it down, deflate, fold, transport, again inflate. So, if the fabric cannot take many folding and unfolding cycles, then after using for two three times it might start getting cracks. So it is important to have flexural and abrasion resistance. So, these are just to show you the full list for those who came in late. This is the list of desirable properties of envelope material and we are still looking for a fabric which meets all these requirements perfectly.

So the cost for a good LTA envelope is not over. Nobody can say that yes we have achieved all these qualities. Large number of research projects are going on all over the world, many companies are developing new fabrics to meet some requirements better than the ones available previously. We also have some very good papers written by experts in this area which also I will load. Please understand this is a postgraduate elective course.

So, not everything will be covered in the class. Not everything can be covered in the class, lot of self reading is expected. So, do not think that the questions or expectations are only to understand what you heard and memorize what is there in the notes you have to go beyond that. So, a large amount of reading is expected to be done by you. I will help you by uploading on Moodle the required literature or pointing out where the material is available, but you need to do some self reading also.