Lighter Than Air Systems
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Lecture - 39
Effect of Superpressure

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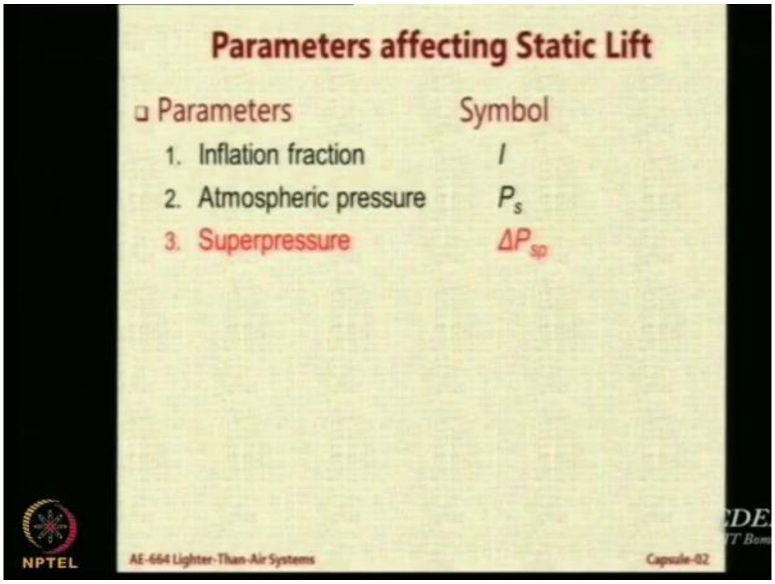

So, we have look at inflation fraction we found that all you need is a ratio of the pressure and temperature. We look at the atmospheric pressure. We found that is superheat is not there is no change in the net lift. Otherwise, there are two terms one is the weight of the ballonet air. That is the gross lift. Both of them depending essentially on ΔP in one case we divided by T plus superheat in the other one we divide by only T and you have K into V as the constant parameters.

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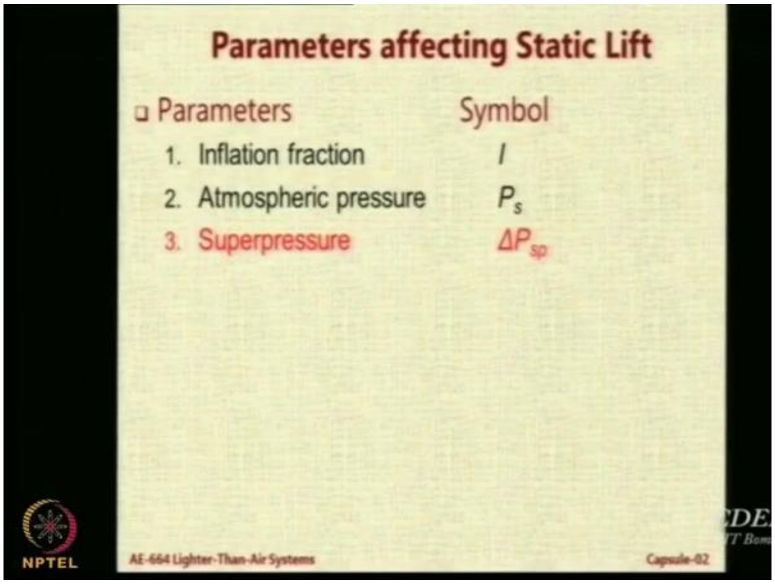

So, now we have to look at superpressure and superpressure alone. Now what happens if the superpressure increases. So, first thing is when you have high superpressure then lifting gas is going to be compressed slightly, that is what superpressure is. So, what will happen is that will force the ballonet air to go out. So simply there will be lower or there will be higher I there will be lower I also. Why should be low? If you are compressed air, because the gas is also compressed.

Now more ballonet air will be sucked into maintained the envelop shape and volume because if you do not do that then the shape will alter and all our assumption will be invalid if the volume changes, we are assuming that the envelope volume is maintained constant. Because when you apply when you apply pressure to a gas. Is the pressure inside? Correct superpressure is the pressure of the gas inside, LTA gas inside.

So that is why when the pressure of the gas increases slightly it will push out the ballonet air that is what I am saying it will push out the ballonet air. How do I express, explain it? See the total volume available is the same. So, if we apply pressure on the gas then; suppose we do not allow anything to go out then what will happen this pressure of the gas is going to act on the envelope and also on the ballonet.

And if you do not allow the ballonet air to go out then there will be a compression of the ballonet and I am assuming that gas is a quantity inside the envelope which is being pressurized. So, you are right in saying that this gas under pressure will exert the pressure or convey the pressure to the surfaces inside on the ballonet. But when you take a take a cylinder for example there is gas inside, you increase the pressure.

What happens to the gas? In this case the volume is not decreasing, point taken. So, we can say that the gas is going to exert pressure on the ballonet and the ballonet will have the pressure to push the air from the ballonet out but the ballonet is going to resist back by sucking in more air to maintain the volume. See it depends on whether you are looking at a close system or an open system.

If you look at an open system when we consider that the ballonet is in contact with the atmosphere always. In that case we can say air is being sucked and the pressure is applied to the gas inside. When I say superpressure, I basically mean that when we fill the gas in the envelope I can fill the gas in the envelope at a pressure equal to atmospheric. So what will happen is that there will be zero differential pressure between the gas inside and outside.

But I filled the gas with higher pressure and then I lock it or a close the valve. That is what is called superpressure. It is not because of the pressure from the ballonet. It is because of the intentional pressure that you put. So, consider a case where there is no ballonet just to make matter simple you can consider superpressure which will be pressurized balloon. When you have a when you have a ballonet and envelope now you fill in air at high pressure.

So, the ballonet is at some volume let us, say they locked in a closed system. Now I will push, I push the gas at more pressure or I just increase the pressure of the gas inside. That is what we have discussed here. Now if we assume that we are not crossing the pressure height which is always the case in all our calculations. Then the weight of the gas inside is going to remain the same. Any how the gas remain the same we are not putting more gas.

We are putting the same was under higher pressure. So, if you look at this; now look at the expression further and where is the ballonet air. This is the same thing which is copied and pasted here. Ratio of the pressure and temperature (1 – I) into K into V. Here I ignored the continuation of e. So, the difference in the two of them ΔW_{ba} it will be essentially if we keep running the P_s is same. We are changing the ambient air pressure we are just changing the superpressure inside.

So therefore, it will be P_{SP1} and P_{SP2}. So, the difference will come because only P_{SP} therefore earlier we got $P_{S2} - P_{S1}$ because we ignore superpressure. Now, we ignore P_{S1} and P_{S2} change we only get $(\Delta P_{SP2} - \Delta P_{SP1})$ into K V upon same $T_A + \Delta T_{SH}$. Now the net gross lift. The net lift is basically the gross difference minus the ballonet air weight but the gross weight is not going to change.

The gross lift change is only if; what is gross lift? Essentially gross lift is equal to the volume of the air displaced by the airship now that will not change unless the location changes between density changes or the volume changes. So therefore, gross lift change will be zero there will only be a change in the air in the ballonet because of the superpressure. Earlier there was some superpressure now there is difference superpressure.

So, therefore the net lift actually will be negative if we increase superpressure. That means if we increase the superpressure actually net lift is going to go down not up you have a minus sign there. Is it clear why it happens? Why does it go down? That seems logical to you but when you increase superpressure that means P_{S2} more than P_{S1} the net lift actually be; it is very simple we put in the expression and see it.

Because understand that ballonet is actually weight. It is not lift ballonet is negative ballonet is; air in the ballonet is not helping us. Air in the ballonet we are force to put it. So, what is happening here is the air is being sucked in therefore the net lift will actually reduced. So, when superpressure increases net lift reduces. Now the other way around suppose superpressure decreases that means you are filling in the gas, but at a lower pressure.

Of course, it has to be at least equal to atmospheric pressure otherwise it will cave inside, but you can put it 500 Newtons per meter square more or 1000 Newtons per meter square more let us say you may 1000 or may have 100 you have reduced it. So, what will happen now the LTA gas will expand to fill the envelope and push the ballonet air out. When you push the ballonet air out actually you save on weight because now you are less air inside so the net lift will increase.

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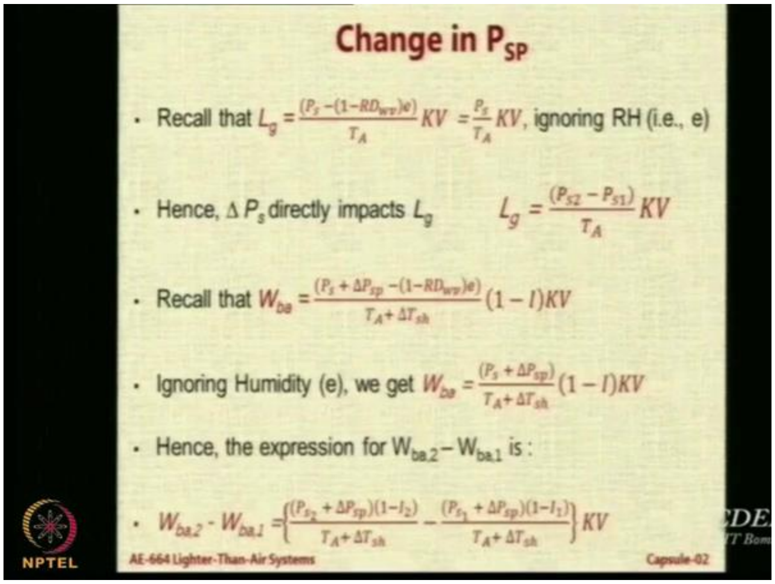

Now, coming back to the same expression lifting gas; the gross lift now I want to take care of the other factors. So, the expression remains the same

$$L_g = \frac{(P_s - (1 - RD_{wv})e)}{T_A} KV$$

so ignore humidity you get

$$L_g = \frac{P_s}{T_A} KV$$

So therefore, this is the same expression we saw last time so I just; so there is one difference between this and the last one. Has somebody notice the difference? I shown the same slide before when I talked about change in P_s actually the title should not P_s it should be P_{SP}.

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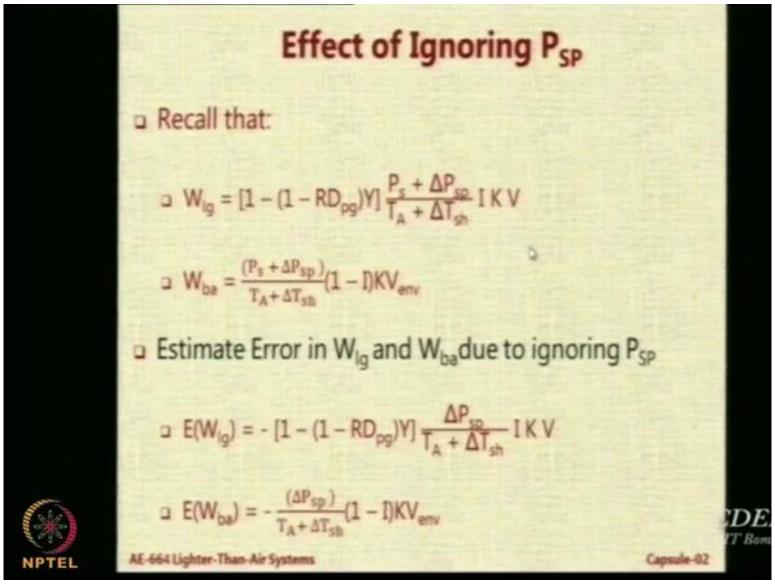

It should be changed in P_{SP}. So, this portion is the same the difference will come when you look at the ignoring of the P_{SP}. So, we recall that the weight of the lifting gas is obtained by this long expression. Here I have put their relative density of the lifting gas. So, in these expressions let us estimate the error in W_{lg} and W_{ba} by ignoring the value of P_{SP}. So, can you figure out the expression for that?

So, basically, what you do is to calculate W_{lg} with P_{SP} considered and then without take the difference upon W_{lg} when it is considered into 100%. So, it will be you can just try yourself what you will get. So, interestingly the terms are there is a term in the bracket which will remain kind of constant because we are not looking at change in the humidity. We are not looking at the change in the purity of the gas, which is why we are just looking at change the ΔT_{SH} and ΔP_{SP}.

So, what you doing you get the expression. And the differences of the two divides by whole expression. So things like I, K, V and this whole square bracket will be there in both the expressions they will all knockoff.

So, how much error is created depends on the numerical values of parameter like I, K, V etcetera. So, for any operating condition we can calculate the error. We will do this question later. It will affect I, but what has happened is if you see the calculations there is some I and there is in the beginning and then there is some I in the end I_1 and I_2.

And by using the expression with relationship between I_2 and I_1 which is P_1 by P_2 we can eliminate the effect of I, that is what we have done.