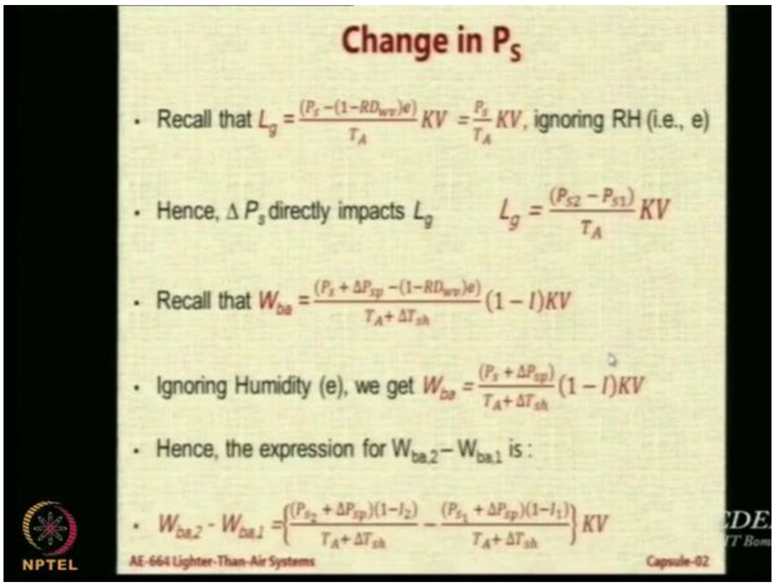
Lighter Than Air Systems
Prof. Rajkumar S. Pant
Department of Aerospace Engineering
Ambient Institute of Technology - Bombay

Lecture - 37
Effect of Change in Atmospheric Pressure

(Refer Slide Time: 00:31)



Now let us look at the difference of the atmospheric pressure. Now we will look at that situation where maybe at the same altitude ambient pressure is not equal to the standard value. So let us recall from our previous slides now unless you read them up regularly you will not be able to appreciate but I cannot do much about it, it is your job to go back home and look at these slides and get familiar. Just for you to recall the gross lift of the envelope basically we derived in the class that it is equal to the total pressure P_s at the altitude minus (1 - RD_{wv}) times e. where RD_{wv} is the relative density of the water vapour.

And e is the humidity so how do you estimate humidity? RH/100 so value of e is RH /100 and this particular term on the numerator, which is subtracted from P_s is the effect of relative humidity. We saw that the effect of around 1.6 to 2% but still for completeness you want to leave the term there into K V upon T_A. What is T_A? The ambient air temperature and what is K? What is V? V is the envelope volume and K is the constant.

The value of that is point zero see the value of Pi is 3.1416 this value is 0.03416 something like that. So, it is a constant K because it only involves ρ_0, T_0, P_0 which are constant values. Now if you ignore the value of e or let us say it is equal to zero then the numerator will have only the P_s term. So will have a simple expression and now if I take two conditions condition 1 and condition 2 or from operating condition 1 condition 2, I want to see if the P_s changes from P_{s1} to P_{s2} what will be the change in the gross lift or L_g.

So, from the expression above you can always work out that are same here because the only thing changing here is the pressure, we are assuming that everything else remains constant only the pressure changes. So that ΔL_g will be this is not correct this should be ΔL_g.

So, the change in L_g will be

$$\Delta L_g = \frac{(P_{s2} - P_{s1})}{T_A} KV$$

Now we also want to recall that the weight of air in the ballonet it was obtained using a very similar expression as

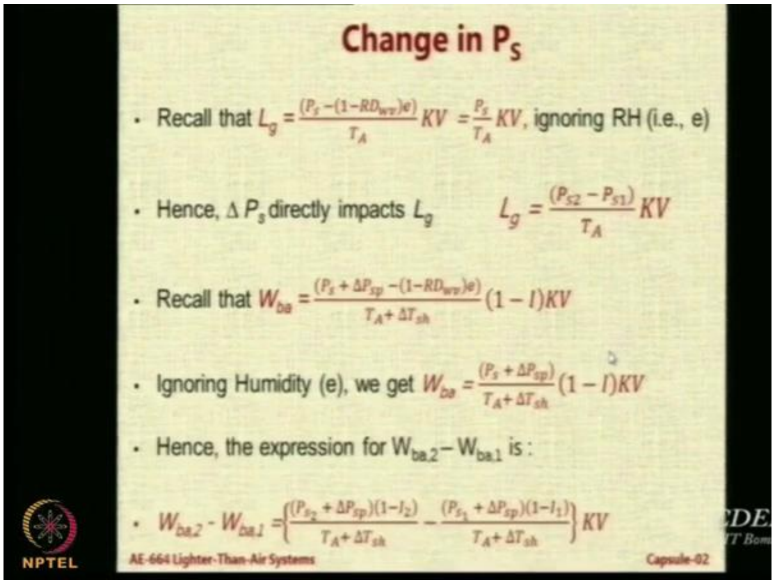
$$W_{ba} = \frac{\left(P_s + \Delta P_{sp} - (1 - RD_{wv})e\right)}{T_A + \Delta T_{SH}}(1 - I)KV$$

So, just like we do the calculation for the lifting gas the same calculations we do also for the ballonet only thing is, this is a computation which also has the super pressure and super heat effect.

Suppose we again ignore humidity because it is only 1.6% or so. So, you will get a simple expression by knocking of this term in the numerator. And now $W_{ba_2} - W_{ba_1}$ will be the difference in the ballonet air weight. So, in this in this expression you first put P_s is equal to P_{s_1} and then you put P_s is equal to P_{s_2} and in the first place It will be $1 – I_1$ and then it will become $1 - I_2$ recall that the inflation fraction will change even though we are changing only P_s.

But the effect of that is also to change the inflation fraction. The moment air in the ballonet is expelled or taken the inflation fraction cannot remain the same. So, the difference of the two expressions will give you the expression for $W_{ba_2} - W_{ba_1}$. So, going from a condition when the pressure is P_{s_1} to a condition where the pressure is P_{s_2} everything else remaining same. We have one expression for ΔL_g gross lift increment and we have one expression for the change in the ballonet air.

(Refer Slide Time: 05:45)



So, essentially if you look at net lift, I am just copying and pasting it here. And now we can simplify this. How do we simplify this?

So, doing that, I just done it for I have just expanded the whole term for you. Those of you looking at this and nodding your head you really regret this it better that you write down what I am doing because when it comes back when you come to the calculations at that time, you will not have the slide in front of you. You get the finished product which you can understand only if you have done these calculations.

It is only for ease in communication that we are using the PowerPoint otherwise we are actually supposed to do these derivations ourselves. If you wish I can do it in front of you here if it helps. But it is already there on the screen so it better that you do it. You do it yourself and check whether you get the same expression if not you have to check or if there are some mistakes here you have to tell me. What are done here is the terms which contain I_1 and I_2 I have clubbed them together.

And the terms which are independent of I_2 I have put them in the first bracket and the denominator is the same so it becomes it remains common. Shall we go ahead? Alright notice that we have 2 terms in the numerator. So, if you recall the last few slides and I showed one expression between I_2 and I_1 with related the pressures and temperatures.

So, what we can do is we can use that expression and by that you can actually eliminate what you will find this. So now this particular term has a negative sign. This has a positive sign and both these terms are actually equal. So, quite simply they will get knocked off.

So, here it is recall that

$$\frac{I_2}{I_1} = \frac{P_{s1} + \Delta P_{sp1}}{P_{s2} + \Delta P_{sp2}}$$

and similarly for the temperatures and we are only assuming here that there is a change in P_s everything does not change. So therefore, if you assume that T_{A2} is equal to T_{A1} because there is no temperature change if you assume that the super heat at 2 and 1 are same because we are not assuming any super heat change.

And if you also assume that the super pressure will also remains the same. The only thing that changes is P_{s1} and P_{s2}. So, when you do that, you can easily see that the term on the right side here will become equal without these two will be equal in these two will be and they will knockoff.

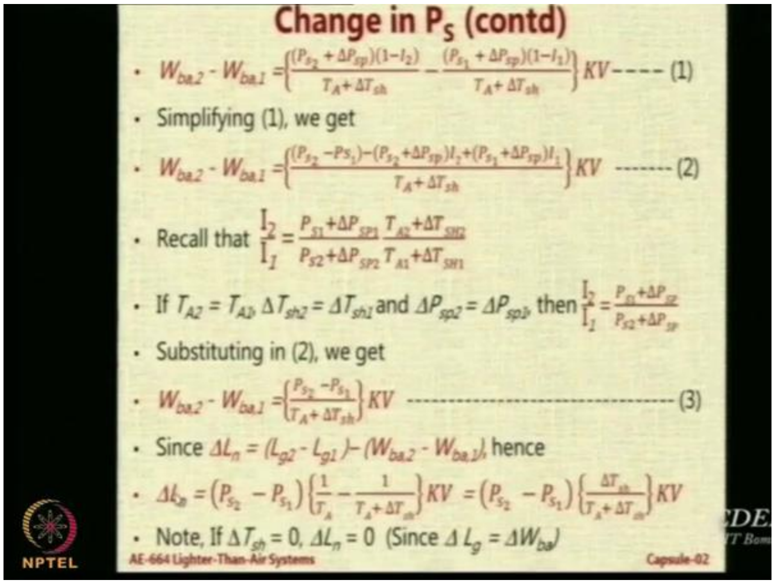
So once that happens that difference in the ballonet air weight is nothing but difference in the ambient pressures divide by the temperature plus super heat times K into V. This expression is very similar to what we got for the gross lift.

For the gross lift if you recall we got a similar expression that the gross lift change is equal to

$$\Delta L_g = \frac{(P_{s2} - P_{s1})}{T_A} KV$$

the only difference is that there is no super heat considered here.

(Refer Slide Time: 10:50)



Here super heat comes into play. So, now the change in the net static lift and that is what our capsule is about. This whole chapter is about change in the static lift because of change in the parameters that is equal to the difference in the gross lift minus difference in the ballonet air weight, is it point clear because this will come every time. Essentially in a system the gross lift is equal to weight of the air displaced.

And the net lift is weight of the gross lift minus the weight of air in ballonet and lifting gas weight itself. So, delta n will be the net gross lift that will be equal to sorry the net lift that will be equal to the difference in the gross lift minus difference in the ballonet air weight.

$$L_{g_2} - L_{g_1} = \frac{(P_{s2} - P_{s1})}{T_A} KV$$

and for change in ballonet air weight

$$W_{ba_2} - W_{ba_1} = \left\{\frac{(P_{s2} + \Delta P_{sp})(1 - I_2)}{T_A + \Delta T_{SH}} - \frac{(P_{s1} + \Delta P_{sp})(1 - I_1)}{T_A + \Delta T_{SH}}\right\} KV$$

So, in the case of lifting gas, we have 1 by T_A in the case of ballonet and we have 1 by $T_A + \Delta T_{SH}$. So therefore, ΔL_N can be easily calculated. What do we learn from here? That the change in the net lift when you simply provide higher pressure. That is wherever the pressure is changing? This P_s change takes place where? This is the atmosphere. So, when you operate from any condition where P_s is equal to P_{s2} compare to when pressure was P_{s1} thereby change in the net lift and that change is simply the difference between the pressures times the ratio of super heat upon T_A + T_{SH} into K V.

Now if you assume that there is no super heat. If you assume that there is no super heat then you find a net lift change is zero. So, this is the interesting observation that if just the pressure is changed without any super pressure without super heat sorry with no super heat, then there is no change. So just by changing ambient pressure and keeping everything else constant including super heat net lift change is 0.