Lighter Than Air Systems
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Lecture - 30
Tutorial Problem 02 and 03 on Static Lift Estimation

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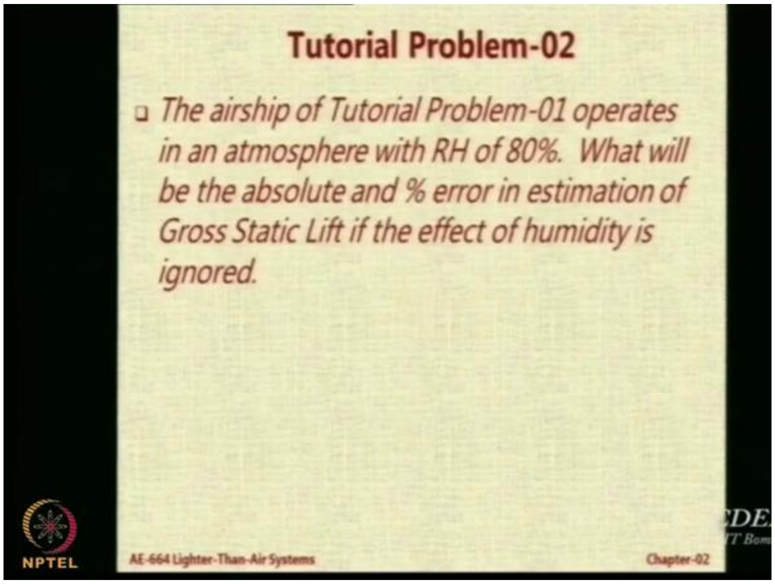

So let us see the difference. So, this is what you will be calculating now. So, the problem that we saw earlier, we assume dry air. Now we say no is not dry it is 80% relative humidity. So, let us see what is the error you get in the calculations? So, to calculate the error first of all we have to find out what is the value of e at sea level. In this case it is actually flying at sea level and that is under ISA conditions. So, which means you have to get the value of?

So, apply this particular formula get the value of e_s for C of 15 degrees Celsius. Don't look at it and please do the calculation. So, C is not zero in this case. C is the ambient air temperature in degree centigrade. So, under sea level ISA condition what is the temperature 15 degree centigrade? So, you put C equal to 15 and get the value of e_s 1695, it was around 1700 correct units will be Pascals so the value is 1695 ok. So, e_s is 1695. And it was 1700 units will in Pascals.

So, the value of e_s is around 1695. So, e_s is 1695 and we have $e = \frac{RH}{100} e_S$. whereas RH is represented in percentage. So, e will be 80 by 100 into this number or 0.8 times that number, 0.8 times 1700,

1356. Now let us go here straight. So, calculate the value of ρ_A with e included. P_s is the ambient pressure at sea level ISA condition which is 101325 Pascals. Value of e just now you got multiplied by value with 0.378 subtracted from 101325 multiplied by 0.003484 divide by the ambient air temperature.

In this case the value of temperature is not centigrade. This is in Kelvin. Now you have to verify what is the value of density you get if you ignore you know this correction. It should come to 1.2256 let us check that is known. One would not do anything; you can just do $\rho = \frac{P}{RT}$. So, if you do $\frac{P}{RT}$ you will get ρ. P is 101325 Pascals, R is 287 kg per degree Kelvin T is 288.16 we will get 1.2256. So, against 1.2256 you get 1.209 then what is the percentage error? So, 1.209 what is the percentage error?

Baseline is 1.2256, 0.44 you are getting, depends on what do you took as a baseline? Base line should be 1.2256. It should be less it would not be so much 0.36 or 0.4 percentage is what I know, it should be 0.4 % write correct 0.4%. Nothing great why are you worry about 0.4% all these huge derivation Dalton's law and Amagat's law blah blah 0.4% that is only true at sea level and that to in ISA condition we will have humidity of 80%.

Of course, humidity cannot be really more than 80, 90 worst is 100% then it will condense. It may see right now that you know, this is the exercise in wilderness but when you do this calculation for let us say ISA + 30 degrees centigrade. You will find this error will be three and half percent, 4% and three and half percent error in the basic; for airships the only source of lift is static lift. Dynamic lifts will only a gift only when you start moving.

So, if you start with a 3.4% error on the basic calculations is not acceptable. So, therefore when you want to calculate the parameter that is important that you have exact numbers with you. So, this we have done now.

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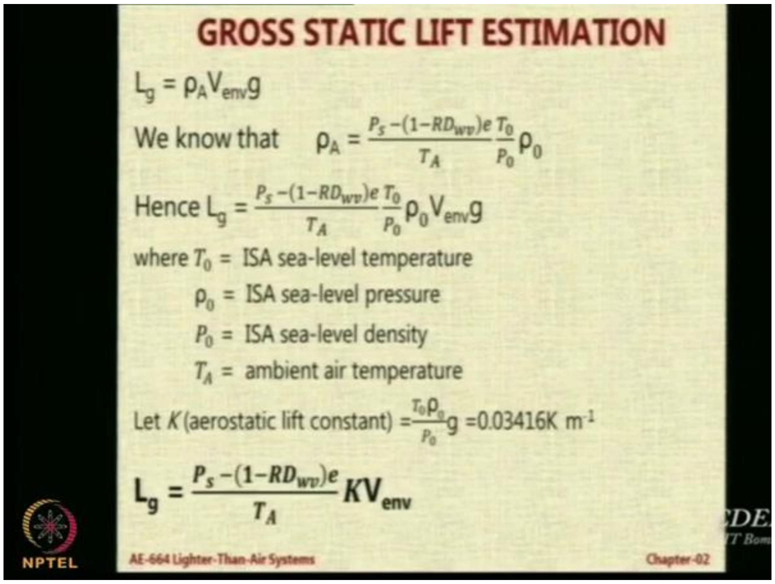

Next concept very quickly to be done is the static lift. So, the gross lift is $\rho_A V_{env} g$. we have already seen this and we also know with all the error in e, which I will correct when I upload this line ρ_A can be related to this number. So therefore, L_g will be just the value of ρ_A it will be that same expression into $V_{env} g$ this is how you can calculate the gross lift. This nothing the same formula with $V_{env} g$ added at the end of it.

Now K is the aerostatic constant this is different from the previous one because now we have g also, so it will be 10 times more. It is constant so you can say that the gross lift is

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

where K is a constant. So, envelope volume is known to you if the relative density is known to you that also known to you $(1 - RD_{wv})$ is actually a fixed number for water vapour so it should not be a problem.

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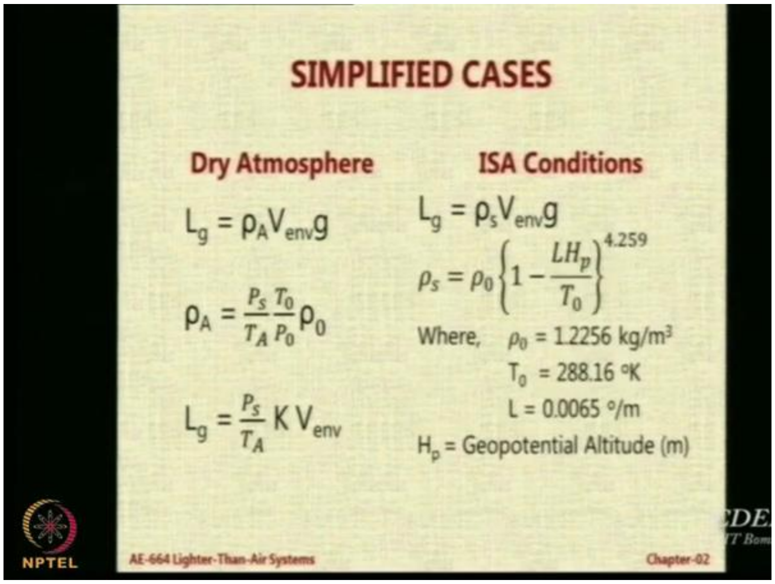

So let us take 2 very simple cases dry atmosphere gross lift is nothing but multiplication of these three things ρ_A already seen before. So, the gross lift is very simple. In dry air ignoring humidity the gross lift is only

$$L_g = \frac{P_s}{T_A} K V_{env}$$

so easy to calculate. But when you have ISA conditions then formula is the same but ρ becomes ρ_s which is the standard ambient temperature and condition.

Now this is known to some students of Aircraft design course and performance courses that density of air up to 11 kilometer in atmosphere can be assumed to vary because temperature varies linearly that is a loss of 6.5 degrees per kilometer altitude. So therefore, $\left(\frac{T}{T_0}\right)^{4.259}$ give you the temperature ratio to the power will give you the density ratio. So, ρ_s can be easily calculated for any operating condition in ISA.

Sea level value ρ_0 which is 1.2256 multiplied by 1 – L, L is a lapse rate. I am taking Lapse rate as positive actually L is negative you can say one plus negative number but be very careful. You should blindly apply formula you make a mistake. The value of L is 6.5 degree loss per attitude but it is taken as plus because the formula already has negative. So, by this you can calculate the value of ρ_s. ρ_s is known to you V_{env} is known to you multiply by g you get the value ρ_g.

This is ISA conditions and we are not assuming any Ballonet present. This is what we did also; this is what you calculated few minutes ago.

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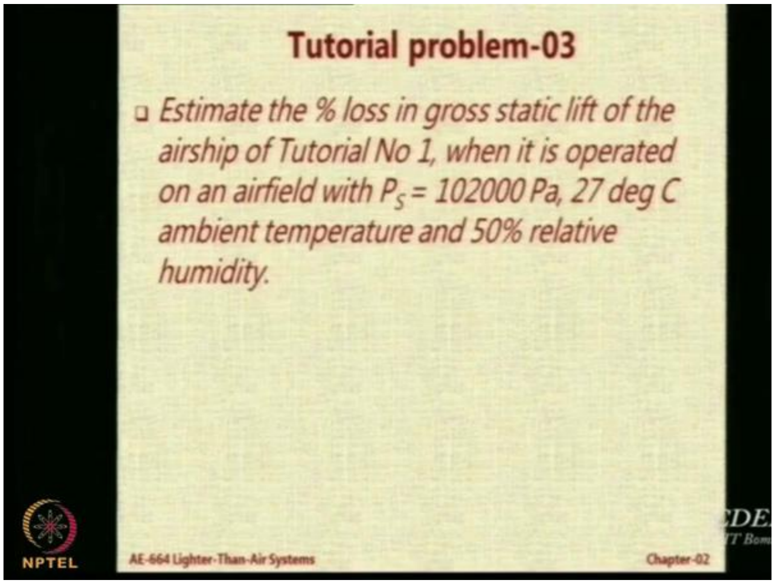

Now the last problem that I wanted to do today is I want to calculate the percentage loss in gross lift when it is operated in airship filled with pressure as 10200 Pascal temperature 27 degrees centigrade and RH temperature. And to calculate this what are the steps you will follow. First thing you will do is we will calculate the value of density of air at this condition. So, now the ambient temperature is also going to play a role.

And the ambient pressure is also not 101325 but it is some other number. This is some airfield where we read the values as 10200 and we calculate the temperature. So, what steps will you follow? The first thing you calculate is the saturated vapour pressure that is the value of e_s. So, for that the same formula as before the value of C will be 27 degrees. So, the first thing I need is how many Pascals do we get? 3548 seems to be ok is this is approximate formula right ok. But exact formula gives 3566, you get 3548 negligible differences. So, we will accept it.

So, the first thing you will do is you will calculate the pressure. Then let us see. Can you now calculate the value of e which is the actual vapor pressure 50%, 50% of this? Then now let us calculate the value of lift using this simple formula. So, what is envelope volume we are taking 7000? And what is the P_A or the P_s we are taking? 80.8 seems more appropriate 80.8, 80.7, 80.8

kilo Newtons. Now what about the gross lift? This is in Newtons suppose I want to force in kilograms then divide by the value of 9.807.