Lighter Than Air Systems
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Lecture - 44
Revision Tutorial Problem 08 and 09 on Affecting Parameters of Static Lift

In the last class we looked at variation of certain key parameters of the atmosphere on the net static lift of an LTA system. And we could not complete all the 9 factors. The 3 factors are remaining. So, we take those three factors today one by one and then we will look at some simple related problems so, that the concept can register in your mind.

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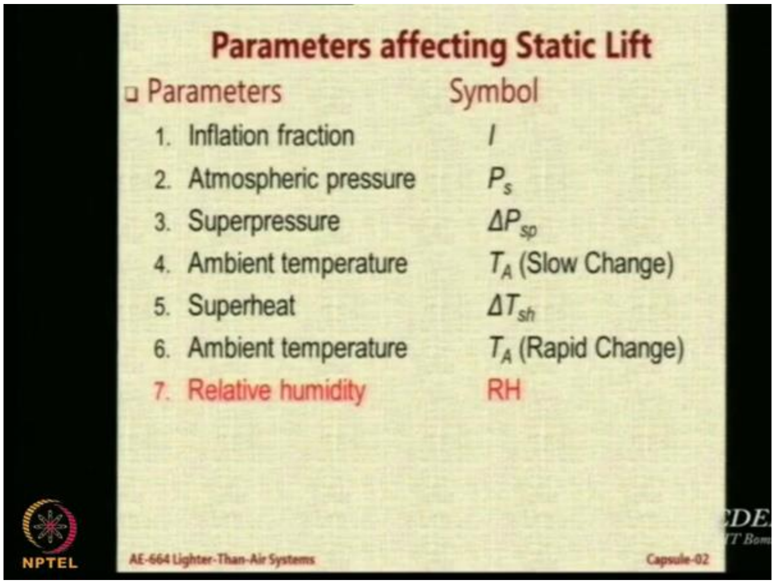

So, the effect of variation of these six parameters the inflation fraction which represents the ratio of the lifting gas inside the envelope upon the total envelope volume the inflation fraction changes, when the airship gains or losses altitude because the ambient temperature and pressure will change and with that there is a direct link between the inflation fraction. Atmospheric pressure comes directly in the numerator of the net static lift calculation.

So, when P_s changes there will be a change in the inflation fraction also and also in the lift. Superpressure essentially represents the pressure in the envelope which is more than the atmospheric to maintain the shape this also, we saw you can model it as a change in pressure or change in superpressure the formulae are very similar. Ambient temperature can change either slowly allowing the thermal equilibrium to happen between the outside air and the inside system.

In that case we saw that there is no net static lift gain but if we do a rapid change in ambient temperature then the system does not get time to respond and hence there is a change in the static lift. Superheat is the heating of envelope beyond the atmospheric temperature due to the radiation that acts on the envelope. We saw that it can be modelled as increase in temperature. And today we look at the remaining three factors.

2 factors and then we look at the effect of that on the lifting gas, volume of the air. So relative humidity is the next.

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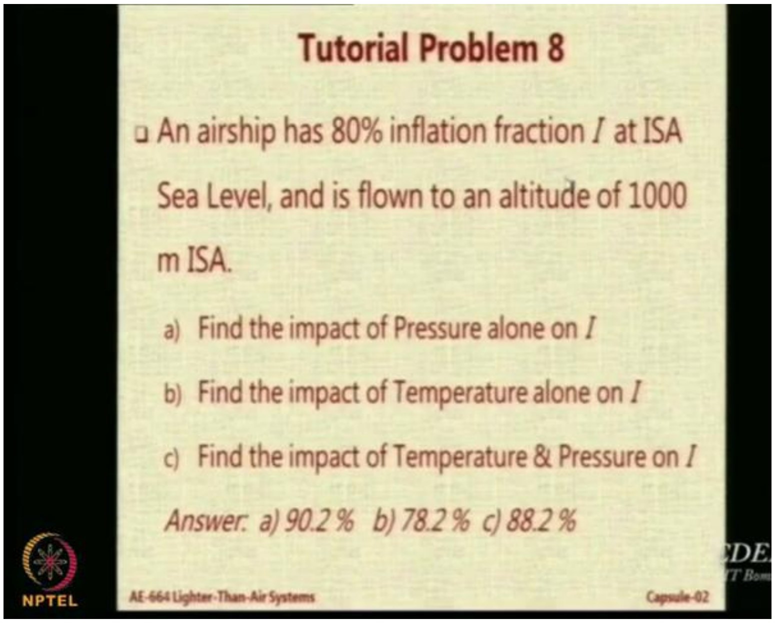

But before we start, I thought let us brush up a few things. So, we will do a few problems that will try to explain the concepts towards more clearly. So, airship has 80% inflation fraction at ISA sea level condition and it is flown to the altitude of 1000 meters ISA. So, do the numerical yourself and see if you can answer of which I mentioned below. First is you are flying to a height of 1000 meters above mean sea level.

How will you estimate the ambient pressure at 1000 meters above mean sea level? These are ISA conditions. So, on that ISA conditions the temperature at sea level is 288 degrees Kelvin and the pressure is 101325 Pascals. How do you get the temperature and pressure at the height of 1000 meters ISA? Let us do it one by one, can somebody answer this question. First of all, how do you go about calculating this effect?

90.2% so, how do you do it you calculated the temperature at 1000 meters by subtracting 6.5 degrees from 288 and then you got the pressure using $\frac{P}{P_0}$ or $\delta = \left(\frac{T}{T_0}\right)^{5.256}$, correct. And then in the formula $\frac{I_2}{I_1} = \frac{P_2}{P_1} * \frac{T_1}{T_2}$ you are just put the same effect of pressure only. Now let us look at the impact of temperature alone how is that? This is to be done in the same way 78.2% and now let us look at the effect of both of them.

You just multiply the two factor that you got 90.2% is just the pressure 78.2 is just temperature and 88.2 which is actually 0.902 into 0.782 into 0.8. That is the effect. So, notice that because of pressure the inflation fraction increases because of this temperature in decreases. And the net effect is an increase so both of them work in the opposite direction.

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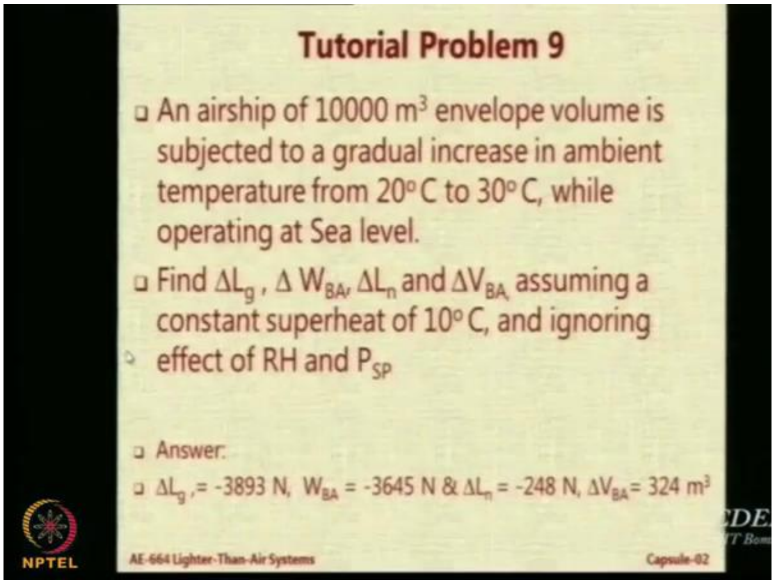

Another problem now the airship is considered to be 10000 meter cube envelope volume and we subjected to gradual increase in temperature from 20 degrees centigrade to 30 degree centigrade and it is operating at sea level. The question is, find the change in the gross lift that is ΔL_g the weight of the ballonet air, change in the ballonet air volume and change in the net static lift. So, we are looking at changes in the gross lift where the ballonet air, net lift and the volume of the air in the ballonet.

So, what is the formula for change in the gross lift because of slow increase in temperature. Do you recall the formula, so the ambient air pressure P_s will remain the same? Basically, the gross lift should be equal to the ambient air pressure into K into V upon T that is the simple formula used to neglect the effect of lifting gas purity. It is just is just the pressure into K into volume upon the temperature.

So, temperature in now becoming from T_{A1} to T_{A2} so therefore

$$\Delta L_g = P_s\left\{\frac{1}{T_{A2}} - \frac{1}{T_{A1}}\right\}KV$$

So, V is 10000 meter cube T_{A2} is 288+30 T_{A1} is 288 + 20. Yes, I am just adding to the value 288.16 is the sea level value but here there is question of sea level, you are given the value. So, you just 273 plus whatever number is given. So, 293.16 and 303.16 the value of K which is the constant is 0.03416 and the pressure at sea level is 101325.

So, please calculate the number and tell me what is the change in the gross lift and also please tell me whether that change is positive or negative. By heating the lifting gas are you going to get a positive or a negative change in the gross lift? It should be negative nothing wrong, the gross static lift is going to decrease if you heat or ambient temperature increases. But the same cannot be said for the net static lift.

Now the weight of the ballonet air what about now there is 10 degree constant superheat that means the envelope has now got a temperature 10 degree higher than ambient temperature because of the superheat. The temperature of the gas inside is 10 degrees than atmospheric because of superheat. Now the weight of the ballonet air is also given by the same expression.

But now T will be the temperature plus the superheat. So, it will become 303 + 10 and 293 + 10 everything remaining the same. So, the numerical value which was -3893 earlier it will come down then I should say there will be a positive addition to that so it will become less negative. What is the ballonet air weight change ΔW_{ba} -3649 that is reasonable 3649 Newtons. Now let us look at the net change in the static lift.

This will be the net change in the gross lift minus net change in the static lift. Earlier we got minus 3893 now you got minus 3649 so the difference between them is the change in the net static lift. Be careful about the signs. So, will the net static lift increase or decrease? Why should increase but so the decrease in lift is how much 3898 so ΔL_N will be ΔL_g is – 388 from that you minus minus of that.

So, it will decrease by around 248 or 249 Newtons so the net lift has decrease. Gross lift has decreased by a lot but now ballonet air has also been taken out. So, the net lift will be 240 Newton reduced. Then what will be the weight of the ballonet air? This is very simple; you know the ballonet air mass. You can use the density of the air at ISA level condition to calculate the value.

So, what is the volume occupied by the ballonet? But be careful you might have mainly ignored one aspect that the density of the ballonet air will not remain same sea level because there is a temperature change. So, the density of the ballonet air is considered to be the same. So, the density of the ballonet is basically the pressure which is 101325 into K value upon the new temperature which is 298.2 plus 10 degrees.

So, there will be change in the density of the ballonet air. So, what is the density of the ballonet air. from 1.2256 it is going to change because the temperature. What density we get for ballonet air? It will be 101325 into K divided by new T which is temporary higher than the superheat 1.16, I am getting 1.14 something, 1.1454 is what I am getting. So, what is the temperature we have taken in your calculations in the in the denominator?

How much is it? earlier it was 298.2 plus 10, no, look the temperature was 293 and it became 303 so what will you take? Will you take 293 or will you take this one? But why have taken that because that is only when it attains that temperature. So, one or take the mean of the two. So, if you are waiting and you are saying I wait till the whole system equalizes and the temperature conveys to the gas inside.

Then you can the temperature has become; so, one can either take the mean temperature or one can take the maximum temperature. So, you take the maximum temperature. So, if that is the case what is going to be the volume? What is that? More than the volume of the gas, 10000 is the volume of envelope. How can the ballonet be 10700? First thing is, please check the units because the value of ballonet air weight, ballonet air is in Newtons and if you use density then it is kg per meter cube, so be careful about unit first of all.

That is the change in the ballonet air weight of 3645 Newtons. So, first you convert into kilograms if you want to work in kg per meter cube. So, the volume of the ballonet air is going to be the change in the ballonet air weight divide by Rho into g. How much is that? Yes, it is it positive or negative. Is it positive or negative 329, whether is it plus or minus? Negative that means the ballonet air that ballonet is going to expel the air.

This is expected when you have superheat and you are heating the body you except that the ballonet will be throwing out the air. So, there are number here for you.