Fundamentals of Gas Dynamics
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Week – 05
Lecture – 19
Using Gas Tables

This class we will introduce something called Gas Table. This is the table, so I will write down the details so that you can buy this.

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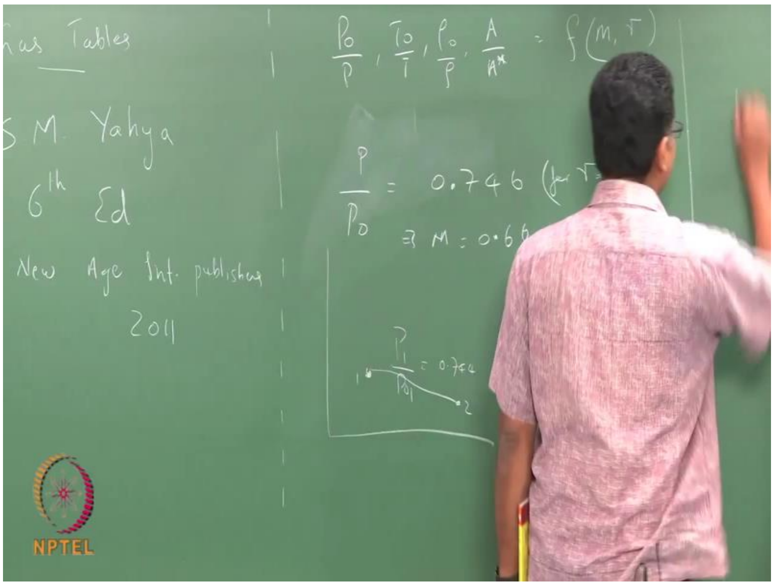

By S M Yahya, 6th Edition, we can also look for the latest edition if you want New Age International Publishers, and this is year 2011. At present we are going to discuss only something called the Isentropic Tables, which is typically what we have seen P naught by P, T naught by T, rho naught by rho, then A by A star, etcetera function of Mach number and your ratio of specific heat. If know this ratio I can find the Mach number or if I know the Mach number I can find P naught. So, the examples that we have done before say for example, if my P naught is T by P naught is say this is more than 1 so this would be 1.4 for a fluid of; in this book the ratios are given.

Let us take P by P naught to be 0.74 if I have state 1 were my P 1 by P naught 1 is given by this value and this undergoing some value where it reaches 2. If I know this ratio I can essentially get my Mach number from this relation which we have already derived, so that Mach number in this book is going to be 0.66 for gamma equals 1.4.

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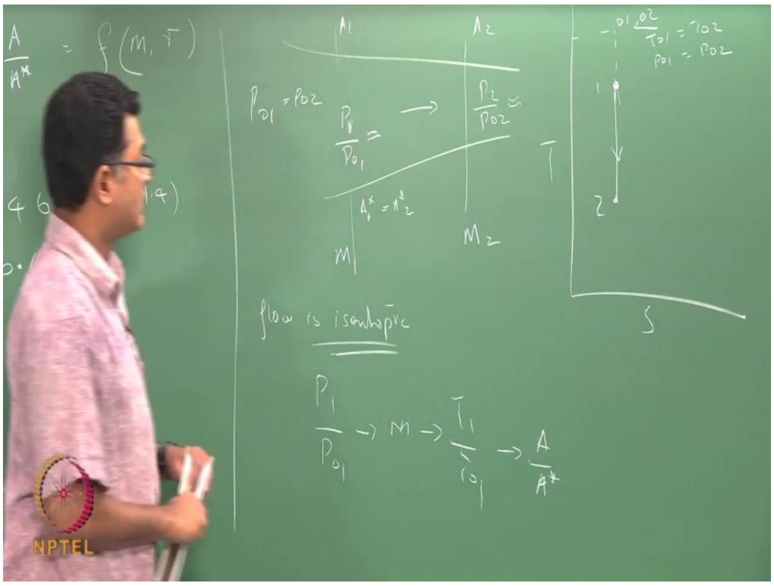

If I have a variable area duct, if I know this stagnation and static pressure I can find the Mach number here at 1 and Mach number here at 2. Now if the flow is isentropic, so the process of fluid at 1 going to stagnation point, the imaginary process that we have already assumed to be isentropic. In addition to that we have been assuming the entire floor to be isentropic then in the T S diagram you would get state 1 going to state 2 in a straight line here, so that there is no entropy change. The stagnation point here at 1 is 01 and that associated with 2 02. Since, it has been isentropic and that there is no heat and no shaft work we know that T 01 equals T 02 and P 01 equals P 02.

If I assume that my P 01 here is same as P 02 for this entire process if the flow is isentropic, which means if I know this ratio we can get the associated Mach numbers, and if I know the value of stagnation pressure which is same along the stream line I can find the pressures at each on those. And if I know the pressure ratio I get my Mach number or I can even get my ratios of temperature or my A by A star.

What does A by A star tell you? If I know the area here A star would tell you how much it has to reduce to get m equals 1. And since it is isentropic you know A star 1 equals A star 2 or the A star along the stream wise direction or this direction where the flow is because this is assumed 1 d, the A star or each of these sections are going to be the same because we have assumed the isentropic it is something which we have seen.

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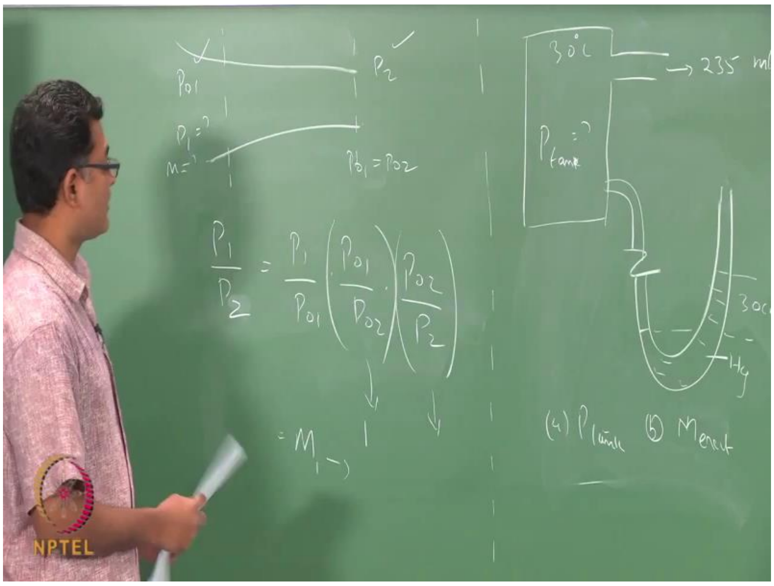

So, this brings in lot of advantage in using your gas tables. For example, if I have a system here, I know P 01 and I know P 2 I want to find say P 1 or the Mach number here inlet Mach number. So what do I do? I try to get this ratio which is P 2, since P 2 and P 01 and rho 2 are given to you, and if it is assumed isentropic P 01 is equal to P 02 so this term is 1, this term is known to you because P 01 is given to you and P 2 is given to you, from this you can get P 1 by P 01. From which you can get your Mach number and hence all the quantities.

So, if we do the problem what we had discussed few classes back or in the last class so let us do that problem again with the gas tables, just to demonstrate how to use the gas table we will do that again here. So, this is a problem that is connected to your u tube which contains mercury and this this distance is 30 centimetre, this is at 30 degree Celsius, velocity is 275 meters per second. The question was to find what is the P tank if you look back the previous lectures. So, the question is what is P tank? What is my M exit? And you be ambient to.

So, you repeat the process what we have done.

Student: P 1 by P 2 is equal to (Refer Time: 10:33).

It is P 1 by P 2 equals P 1 P 01, this thing, this thing, so this is known to you, P 1 is not known.

Student: (Refer Time: 11:02).

Correct. This is P 1 by P 2 or you can even write in another form so you make it into a ratio which is known to you and then get into ratios of these quantities which are easily computable or what you can get it from the tables. We will do this problem and try to see what we have done earlier.

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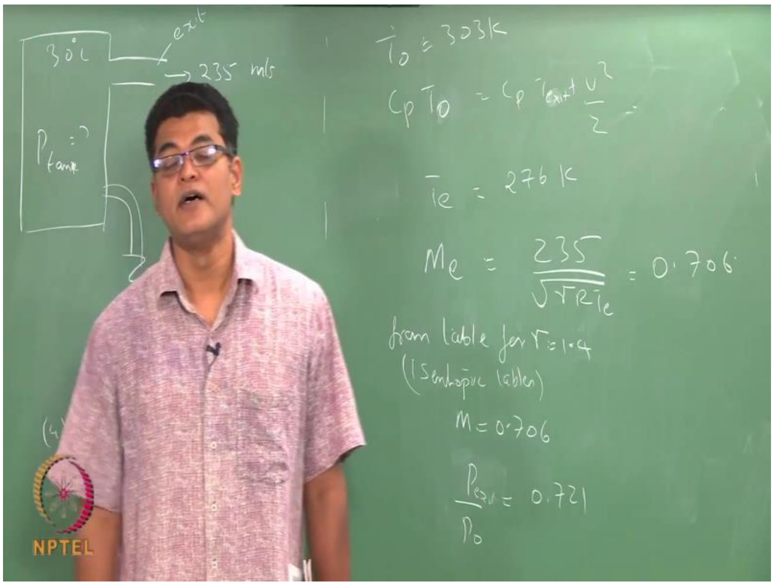

So, my T 0 is 3 naught 3 Kelvin and we have found the exit pressure which is here to be C P T 0 plus v 2 square by 2 and we obtain out exit temperature to be 276, the same process as we have done before. So, the Mach number at the exit is 235 divided by root of gamma R T exit which is 0.706. Now the moment you get the Mach number at the exit you can look at the table 1.4, the isentropic tables because we assume the process to be isentropic. So, for m equals 0.706 I would get my P 0 by P e, so I will take the book look at the gamma equals 1.4, m equals 0.76 0.7 P by P naught is equals 0.721. From this as we have done before you could find your; so this would be your P exit by P stagnation.

Student: (Refer Time: 14:06) C P T equal to (Refer Time: 14:08).

So, this C P T naught equals C P T exit plus this. So the moment you get Mach number you get this ratio, once you get this ratio you can easily find whatever the quantities that we were discussing. So, like what we have done in the previous lecture you can continue doing this. Instead of using this formula we have just used the table that is only difference we have done here.

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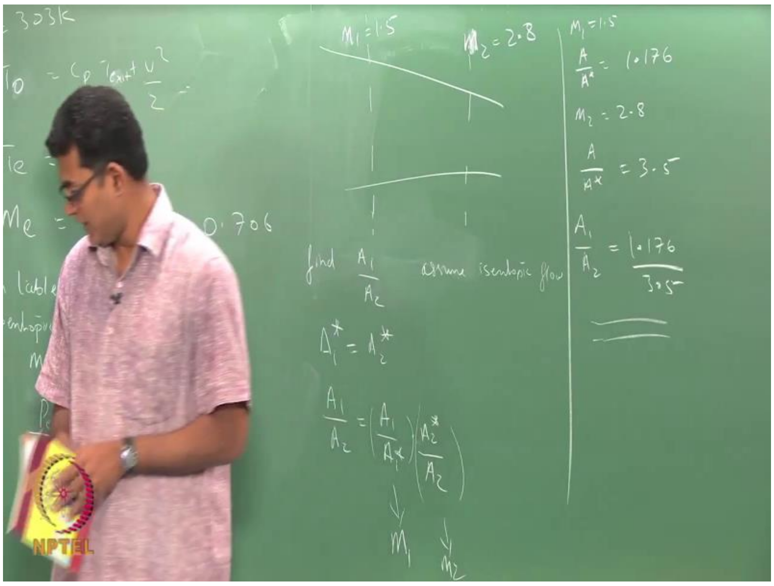

Now same thing if I use this is if I know my A 1 if I know my A 2. So, I know my m 1 I know my m 2, find A 1 by A 2 assume isentropic flow. So, what do you do? The moment I assume isentropic flow my A 1 star equals A 2 star, so my A 1 by A 2 is A 1 by A 1 star into A 2 star by A 2. Now A 1 by A 1 star I can get it from m 1 this is m 2.

For m 1 let us take this is 1.5 and this is 2.8. So, for m 1 1.5 my A by A star, 1.5 I take the isentropic tables for gamma equals to 1.4, m equals 1.5 minus A by A star is 1.176. For m 2 2.8, my A by A star from the tables is going to be 2.8 it is going to be 3.5. So, my A 1 by A 2 is A 1 by A 1 star which is 1.176 divided by this quantity which is 3.5. Likewise, with the assumption you could use A star to be dividing and multiplying this ratio or P star or P 0 or T 0 are to be multiplying and dividing to get here appropriate quantities. Doing this by these ratios which you can compute or look at the tables and get those values is the key to do the gas dynamics problem with the tables.

With that I will stop discussing this, we will use this table from now on to do most of the problems.