Gas Dynamics and Propulsion
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Lecture – 39
Ramjets / Scramjets

So in the previous class, we looked at worked example and we will continue to work it out in this class.

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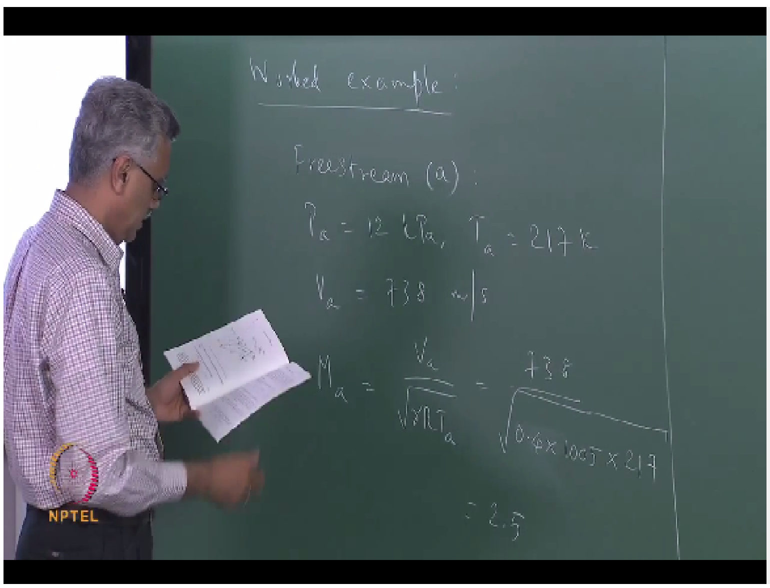

So we looked at a ramjet engine and the free stream conditions that are given like this. So free stream state we denoted as a and Pa was given to be 12 kilopascal and Ta was given to be 217 Kelvin and the velocity Va was given to be 738 meter per second. So let us determine the free stream Mach number Ma, so the free stream Mach number Ma is given as Va/square root of gamma*R*Ta and because this is air, we take gamma to be 1.4.

So I can evaluate this as 738/square root of 1.4*Cp or I can also write this in terms of, let me writ this in terms of the given values which is Cp and gamma are given. So I can write this as 0.4*Cp which is 1005*217 and If I calculate this number, if I substitute the values, I get this to be 2.5. So the free stream Mach number comes out to be 2.5.

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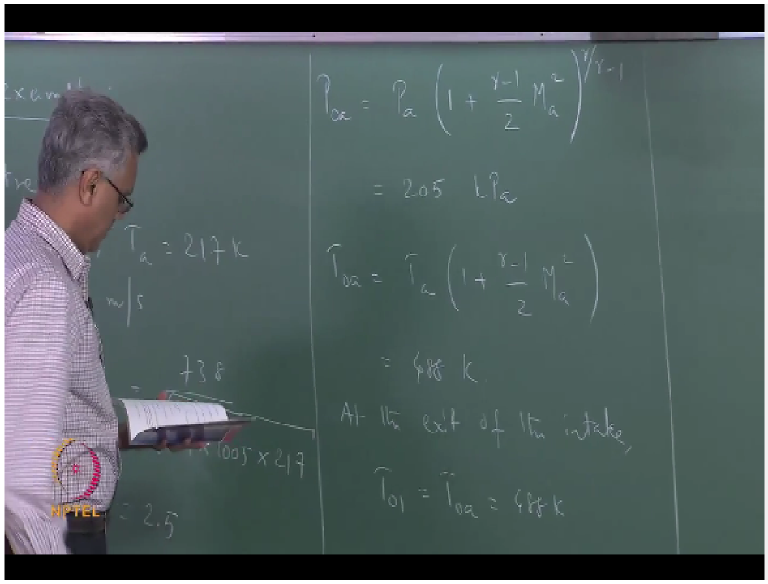

And based on this, I can calculate the free stream stagnation pressure, P0a using the isentropic relationship. So this is P0a=Pa*1+gamma-1/2*Ma square raise to the power gamma/gamma-1 and if you substitute the values, we get P0a to be 205 kilopascal and the free stream stagnation temperature can be calculated as follows, T0a=Ta*1+gamma-1/2*Ma square

And once again substituting the values, we get the stagnation temperature to be 488 Kelvin. So these are the free stream conditions or conditions at entry to the intake. So at the exit of the intake, we denote this as state 1 since there is no heat or work addition, the stagnation temperature remains same. So T01=T0a=488 Kelvin.

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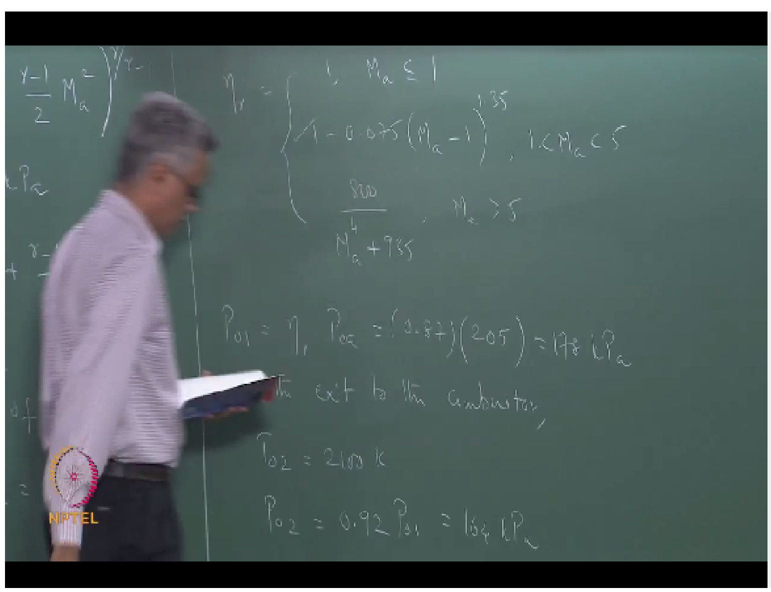

And in order to calculate P01, we need to use the military specification and if you remember, we had written it down like this. So the pressure recovery was = 1 for Mach number < or = 1 and this was = 1-0.075*Ma-1 raise to the power 1.35 for Mach numbers lying between 1 and 5 and was = 800/Ma raise to the power 4+935 for Mach number>5. So in the present case since the Mach number is 2.5.

We use this relationship and if I use this relationship, then I get P01=eta R*P0a and the value for eta R comes out to be 0.87. So 0.87*P01 which we calculated as 205 kilopascal. So this comes out to be 178 kilopascal. So we have calculated both stagnation temperature and stagnation pressure at the end of the intake. Now we go to the combustor. So at the exit to the combustor, the stagnation temperature is given to be 2100 Kelvin. So T02=2100 Kelvin.

And it is given that there is 8% loss of stagnation pressure in the combustor. So which means that P02=0.92, so that is 1-0.08 because there is 8% loss of stagnation pressure. So 0.92*P01 and if you substitute the values, you get this to be 164 kilopascal.

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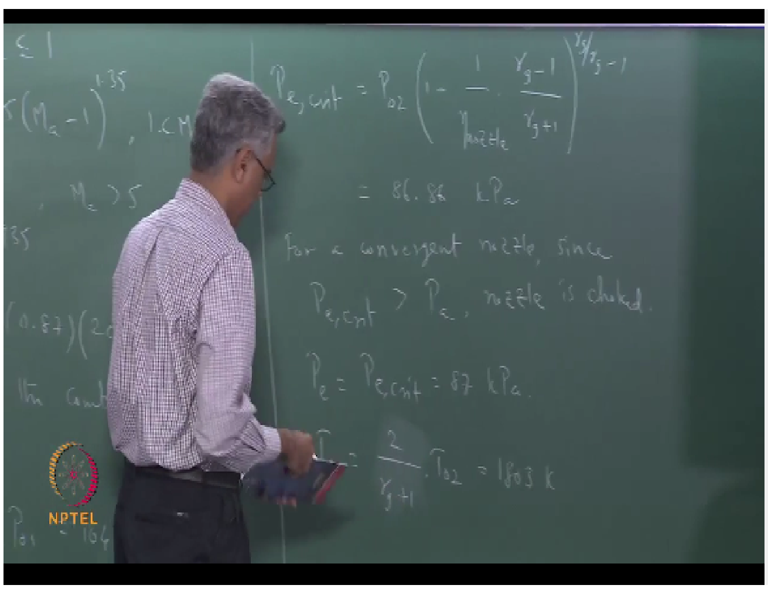

So now we have come to the nozzle. So this is the stagnation pressure at entry to the nozzle. So let us evaluate the critical pressure. So Pe critical is given as P02*1-1/eta nozzle*gamma g-1/gamma g+1, the whole thing raise to the power gamma g/gamma g-1. Eta nozzle is given in the problem statement to be 0.97, gamma g is also given. So if you substitute the numbers, we get the critical pressure to be 86.86 kilopascal or 87 kilopascal approximately.

The ambient pressure, if you recall, the ambient pressure is given to be 12 kilopascal, right. So this was the ambient pressure. So since the critical pressure is greater than the ambient pressure, the nozzle is choked. It is also given that, we are asked to look at 2 conditions, One conversion nozzle, two, conversion-diversion nozzle, okay. So if it is a convergent nozzle, then since Pe critical>P ambient, nozzle is choked.

So the exit pressure is thus = Pe=Pe critical=87 kilopascal and the exit static temperature can be calculated Te can be calculated by using the fact that the Mach number is 1, so this is going to be the 2/gamma g+1*T02 and if you substitute the values, you get this to be 1803 Kelvin.

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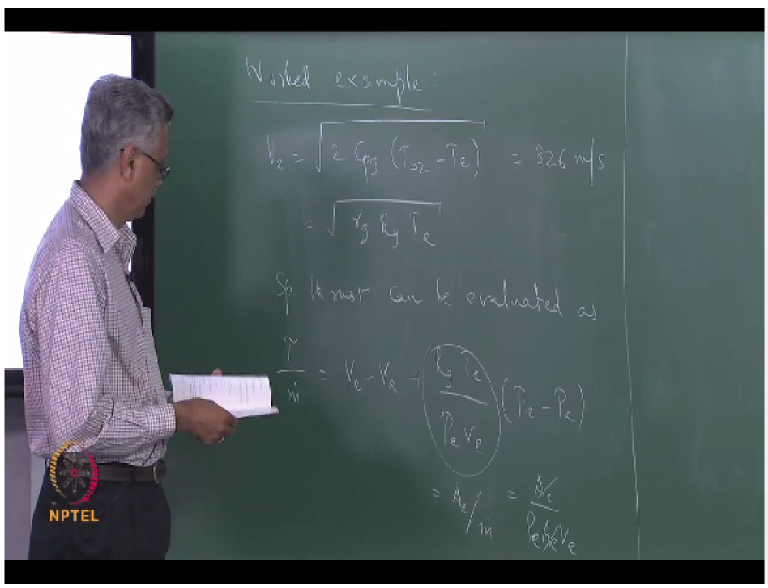

So now that I have the static temperature, I can calculate the exit velocity Ve as follows, square root of 2*Cpg*P02-Te and this you substitute the numbers, this works out to be 826 meter per second. In fact in this case since the nozzle is choked, you could also have calculated this as square root of gamma g*R*Te, that will also give you the same value because M = 1, right.

So this is also equal to… both will be the same, if you calculate using both ways, it is okay because we have already made use of this fact when we wrote this expression, when we wrote this expression, we already used the fact that M=1, right. So both will give the same number, there are no issues here. So the specific thrust can be evaluated, T/m.=Ve-Va+Rg*Te/Pe*Ve*Pe-Pa.

So if you remember this term corresponds to Ae/m. that is what this term corresponds to, right. So let us just quickly take a look at this term, so if you remember this is = Ae over m., right and m. itself is = rho eAe*Ve and that is how we have simplified this term.

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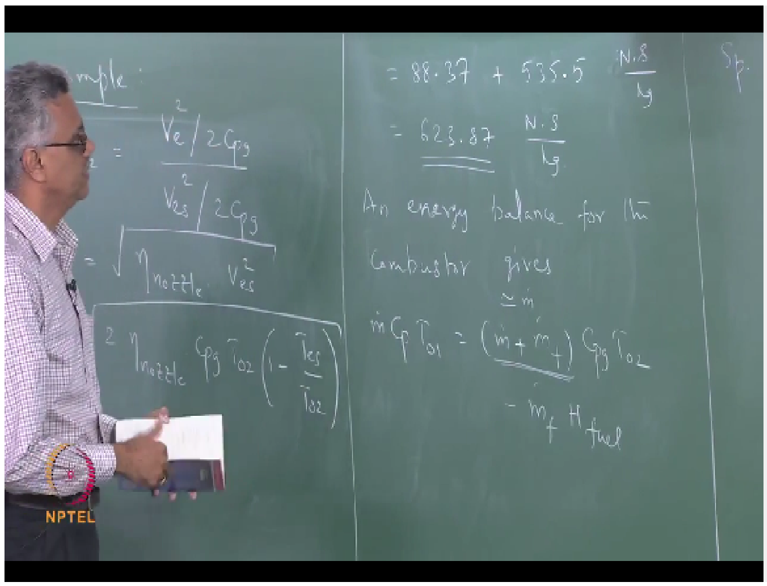

So if you substitute the numbers, the specific thrust comes out to be 88.37+535.5 Newton second per kg, so this works out to a total of 623.87 Newton second per kg. So you can see that the pressure thrust dominates in this case because we have used a convergent nozzle and the exit pressure is far above the ambient pressure. So this says that ideally in this case, we should be using a convergent-divergent nozzle, right which is what we are going to do next.

Now before we do that, we are also asked to calculate the thrust specific fuel consumption, right. So we can do that by calculating the fuel flow rate. So energy balance for the combustor gives m.Cp*T01, we assume steady-state operation here. So m.Cp*T01=m.+mf.*Cpg*T02-m.f*H. So here we are applying the steady flow energy equation to the combustor and coming up with this equation and if you substitute the, if you rearrange, then we can calculate mf./m. as follows.

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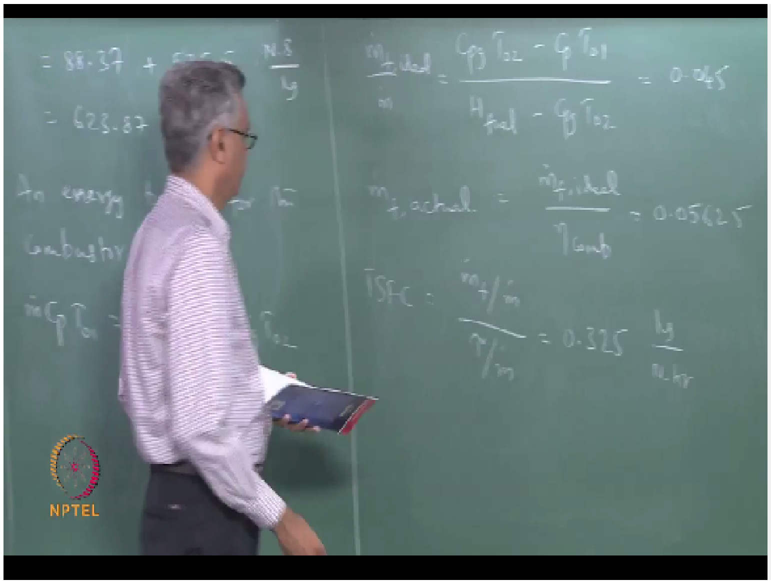

So mf./m. comes out to be Cpg*T02-Cp*T01/H fuel-Cpg*T02. What is that in this term m.+mf., I can neglect mf. in comparison with the m. So I have taken this to be = m. itself. So this is reasonable, we have been doing this. So I have taken this term to be = m. itself. So if you calculate this value, this comes out to be 0.045 under ideal conditions, right. So this is nothing but mf./m. under ideal conditions. Combustor efficiency is given.

So mf. actual=mf. Ideal/combustor efficiency. So the combustor efficiency is given to be in the problem statement, it is given to be 0.8. So which means that I have actually have to burn more fuel to get the same change in stagnation temperature. So this comes out to be 0.05625. So what this tells me is that under ideal circumstances, I would had to burn only 0.045*m. to achieve the peak temperature of 2100 Kelvin but because the combustor is not 100% efficient, I have to burn this much fuel to realise the same peak temperature that is what this means.

So TSFC=mf./m./T/m. and for this I get this to be 0.325, you substitute the numbers, you get this to be 0.325 kg per Newton hour. So we are asked this calculation assuming the nozzle to be convergent and assuming the nozzle to be convergent-divergent. So we have done the calculation and calculated specific thrust if it is a convergent nozzle. Now this part will not change irrespective of the nozzle, this remains the same.

So we will now do the calculation assuming the nozzle to be convergent-divergent which means the exit pressure is not going to be 87 kilopascal but it will be expanded in the nozzle up to the ambient pressure. So the exit pressure will be 12 kilopascal and not 87 kilopascal that is what we are going to do next.

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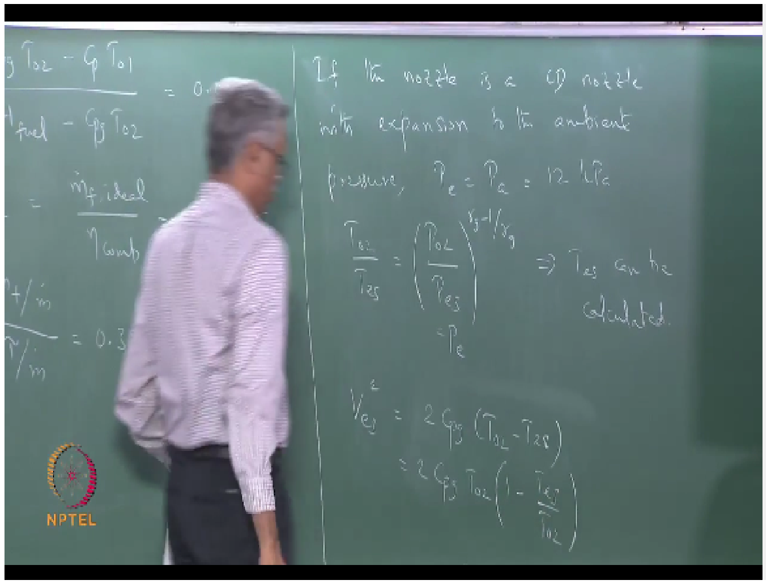

So if the nozzle is a CD nozzle with expansion to the ambient pressure, the Pe=Pa=12 kilopascal. So we need to calculate either Te or Ve, anyone of these 2 things will do. So we make use of the factor T02/Tes=P02/Pes to the power gamma g-1/gamma g because state point es and state point 02 lie on the same isentrope. If you go back and look at our thermodynamic diagram for the nozzle, you will see that these 2 are on the same isotope. Furthermore, for the nozzle, we also said that Pes=Pa.

Because a and es lie on the same isobar, right. So Pes=Pe in this case, right. Pes=Pe. So if I substitute the values, then I can calculate Tes from this. So this is that Tes can be calculated but I can actually, I need not calculate this explicitly, I can calculate the exit velocity by just using this ratio. So Ves square=2*Cpg*T02-Tes, I am sorry, there is no square root here because this is Ves square one and if I pull out the T02 from this, this can be written as 2CpgT02*1-Tes/T02.

This is Ves square and we know the nozzle efficiency. So I can now calculate Ve square from the definition of the nozzle efficiency. Let us go ahead and do that.

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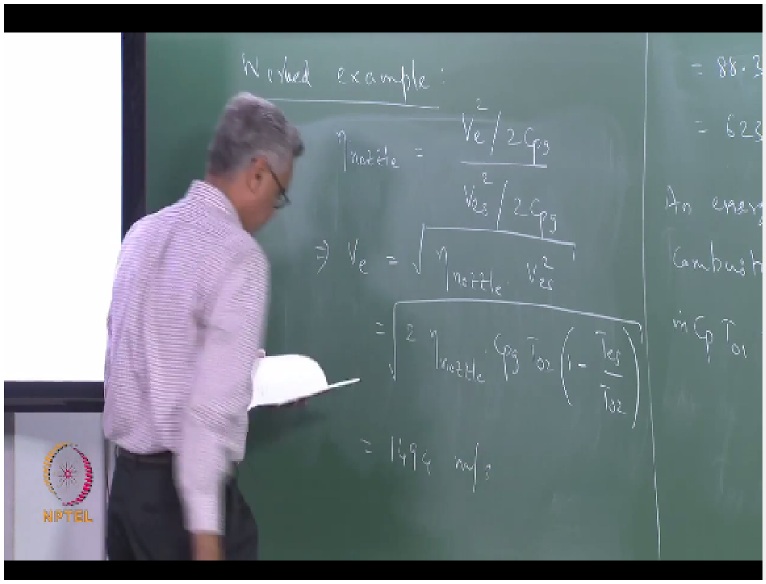

Since eta nozzle=Ve square/2Cpg/Ve square/2Cpg, I can get Ve to be… and if I substitute from there, I get this to be 2*eta nozzle*Cpg*T02*1-Tes/T02. I substituted for Ve square from there and if you plug in the numbers, you get this velocity to be 1494 meter per second. You may recall that when we used the convergent nozzle for the same conditions, the exit velocity was about 820 meter per second.

So now it is almost 1.5 kilometer per second and if you go ahead and calculate the thrust now, specific thrust.

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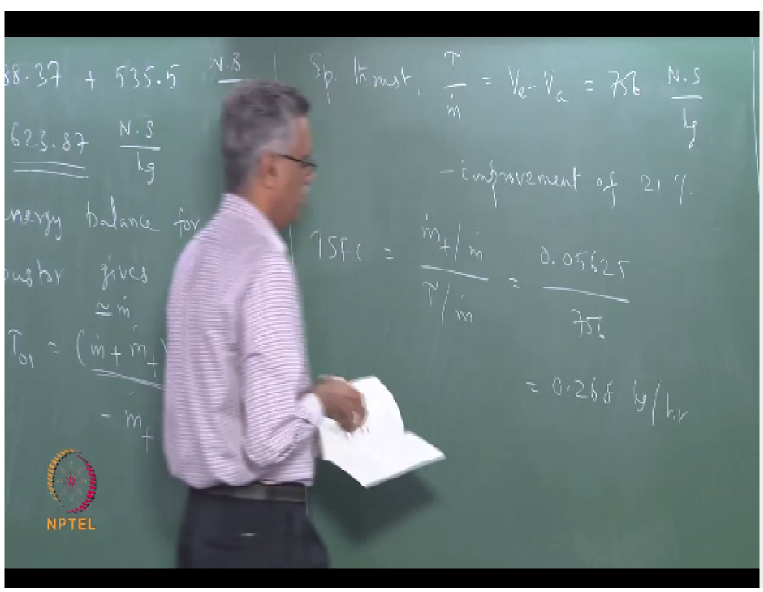

So the specific thrust, in this case, there is no pressure thrust, only momentum thrust. So this is

Ve-Va. So this comes out to be 756 Newton second per kg. So if you compare that with this number, we can see that this represents an improvement of nearly 25%, almost 623, that is 756 that is about 130, so that is about more than 25% improvement in this, okay. Can someone tell me what this improvement is? Heat is more than 25%.

"Professor - student conversation starts" 21%, 21%. (()) (23:17) 21.3, okay fine. So that is improvement of 21%, good. **"Professor - student conversation ends"** And TSFC will change for this case. Absolute fuel flow rate will not change but TSFC will change for this case. So TSFC=mf./m., which remains the same, /T/m. which has changed now. So this is the same as before, right. So mf./m. is the same as before.

So that is 0.05625/T/m. now has become 756. So this comes out to be 0.268 kg per hour compared to 0.325 before. So obviously this is better because for burning the same amount of fuel, I am now getting higher specific thrust, so definitely using a convergent-divergent nozzle in this case is definitely better. Any questions? Okay, so that brings us to the last module in the course, we have seen up to ramjets. What we are going to do now is take a look at scramjets.

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So in the last module, we are going to take a look at scramjet technology. So if you remember in one of our earlier slides, we listed flight Mach number versus technology. So we started with the propeller for low subsonic flight Mach numbers, then we said turbojet for high subsonic flight

Mach numbers, turbojets and turbofans, then are we said afterburning turbojets for going past the sound barrier for brief periods of time for supersonic flights.

And then we said turboramjet for sustained flights at low subsonic Mach numbers, then from that, we said ramjets for sustained flights at supersonic Mach numbers up to about 2 or 3 or so. Now for flight Mach numbers beyond this value, generally beyond 4 or 5, ramjet technology is not really suitable. So that is when we start looking at something called scramjet technology, okay. Why is ramjet technology not suitable, so that is what we are going to see, today.

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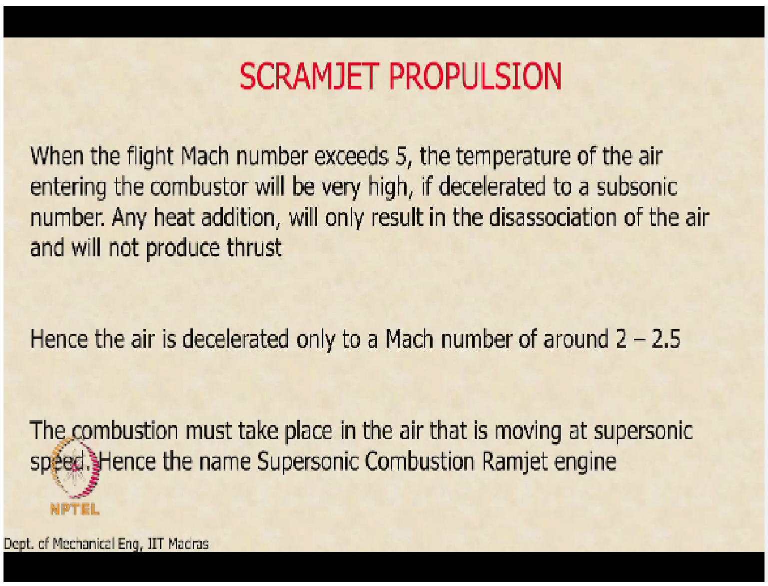

So when the flight Mach number goes beyond 5, okay, remember when we talked about thrust and we said we have to impart a velocity change to the fluid after it goes through the engine and we said that this velocity change can be accomplished by increasing the specific enthalpy of the air or specific enthalpy of the fluid and we increase the specific enthalpy of the fluid by increasing its pressure and by increasing its temperature because the enthalpy is nothing but U+Pv.

So we increased U by increasing T, when we increased P, right. So you increase the specific enthalpy of the fluid and then, in the nozzle, you convert the specific enthalpy to kinetic energy. So that allows the engine to produce thrust, right. So conversion of enthalpy to kinetic energy is the critical part in realising the increase in enthalpy as thrust, right. Now when the flight Mach number exceeds 5, okay, if you use ramjet technology, right, you decelerate the air to subsonic Mach number at the exit of the intake.

From flight Mach number of 5 or 6, if you decelerate to a subsonic Mach number at the end of the intake, remember as the pressure increases in the intake, the temperature also increases. If you decelerate it all the way to a subsonic Mach number, then the temperature of the air entering the combustor becomes very high because of the amount of deceleration that you are doing, okay.

Unfortunately when the temperature entering the combustor itself becomes very high, if you try to increases its enthalpy by adding further heat, this does not go towards increasing the enthalpy of the fluid, it actually causes dissociation of the fluid. So the energy that you are putting in goes not towards increasing the internal energy or the energy that you are putting in ideally should increase U which is the internal energy.

Instead of doing that, what happens is, the energy goes towards breaking the bonds of the molecules in the fluid. So once the molecules are broken, the energy that is used for breaking the molecules is no longer available for conversion to kinetic energy in the nozzle. Remember our idea was to increase the enthalpy in the combustor and then extract that increase in enthalpy as energy, kinetic energy in the nozzle but in the combustor, the energy that you are putting goes towards dissociating the molecules, when this fluid comes to the nozzle, you will have only dissociated molecules.

So you cannot recombine these molecules and recover the enthalpy. It is not possible. So the use of ramjet technology for flight Mach numbers exceeding 5 is not feasible because the increase in temperature itself is so high. So what we do in this case is we decelerate the air not to subsonic flight Mach numbers but only to Mach numbers around 2 to 2.5 that is reasonable. The increase in temperature in this case is also reasonable that there is scope for further increase in enthalpy and increase in temperature which can be converted to kinetic energy in the nozzle, right.

So we decelerate it only to Mach numbers around 2 to 2.5. If you do that, the implication is that the combustion should take place in air that is moving at a supersonic speed, okay and that is where the name supersonic combustion ramjet comes from, okay. In the ramjet combustor, combustion take place at subsonic Mach numbers, whereas in the scramjet engine, the combustion must take place at supersonic speeds.

This is an extremely challenging task. Both this and designing the intake. If you remember, we said that in ramjet, the most critical component is the intake and in a scramjet also, the most critical component is the intake. In addition now, we have added to the list of critical components, the combustor also because of the technical challenge of having sustained combustion and heat release in air which is moving at supersonic speeds.

This is somewhat difficult to swallow because if you remember the ramjet engine has only 3 parts or 3 components. What are the 3 components? The intake, the combustor and the nozzle. The scramjet engine also has only 3 components, intake, combustor and nozzle. So 2 out of the components are very critical. We can imagine how challenging the task is going to be, okay.

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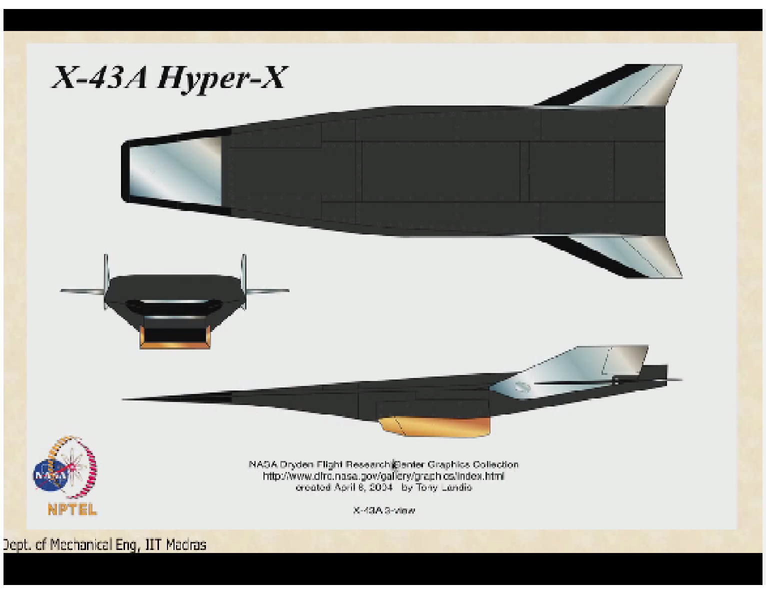

And let us see what is being attempted to realise this technology. So here you are looking at a scramjet vehicle, okay. So here you see the complete vehicle with the control surfaces and here you see side view of this vehicle and you can see the long, almost isentropic kind of intake to decelerate the air from Mach numbers maybe 6 of 6.5 or 7 to perhaps 2 or 2.5. So this is the fore-body where external compression takes place.

So you can see these curved surface which is going to generate oblique shocks which will compress the free stream air and then feed it into this engine. So this is the engine, okay. So this part of the engine is the intake, internal compression intake, we have combustor and then interestingly enough, this part is the nozzle. The nozzle is not enclosed, okay. In this case, normally the nozzle is not enclosed and the flow expands against this surface.

Just like this surface, compresses the air which is moving this way, expansion against this surface will produce thrust which will be a force exerted on this surface in this direction, from right to left. These types of nozzles are called single expansion ramp nozzles. These are completely open and the expansion takes place against the upper surface of the vehicle, okay. Having additional surfaces in this case will increase the drag tremendously. Remember we are talking about free stream flight Mach numbers of 7 or so.

So if you enclose this nozzle that means those surfaces are going to experience drag at such high speeds, okay which is why they are left open and expansion takes place only against this surface, which is why the nozzle, actually this is not a critical component, relatively straight forward, okay. What is critical is this intake and this combustor, okay. So it is extremely simple aerodynamically and it is supposed to develop thrust which will allow it to fly and sustained flight at Mach numbers around 7 or so, okay.

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So here but as we said earlier, the ramjet or the scramjet because it does not have a compressor, it cannot take off or land on its own. So it has to be taken up to the designed flight Mach number and then released. Only then it will start operating. So here you will see, so this is the scramjet which is mounted in front of this missile. The missile itself is mounted underneath the wing of an ordinary aircraft.

So the aircraft takes this entire thing up to altitudes of about 30,000 feet or so and then this missile is launched. So the missile then boosts this to the required altitude of about maybe 30 km or so and then the missile is disengaged and at that point, the intake is opened and the scramjet will start flying at the designated altitude and flight speed, okay. So this is like a 2-stage launch, first stage is using this aircraft, second stage is using this missile, okay.

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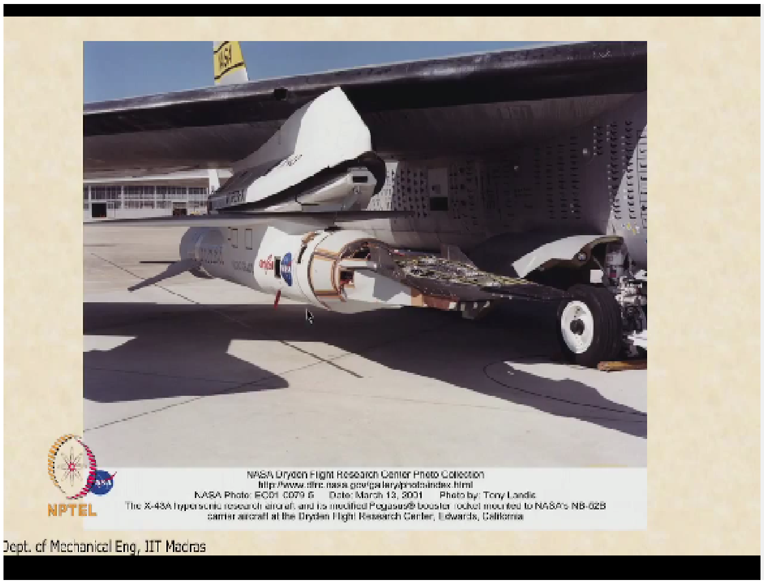

So here you see a closer view of the scramjet vehicle that I showed earlier. So I can see the intake here and you see the engine which is mounted over here. Then you see the whole thing being mounted on this missile, okay and the whole thing is underneath this wing of this aircraft, okay that gives you an idea about the size and so on. This is an experimental aircraft.

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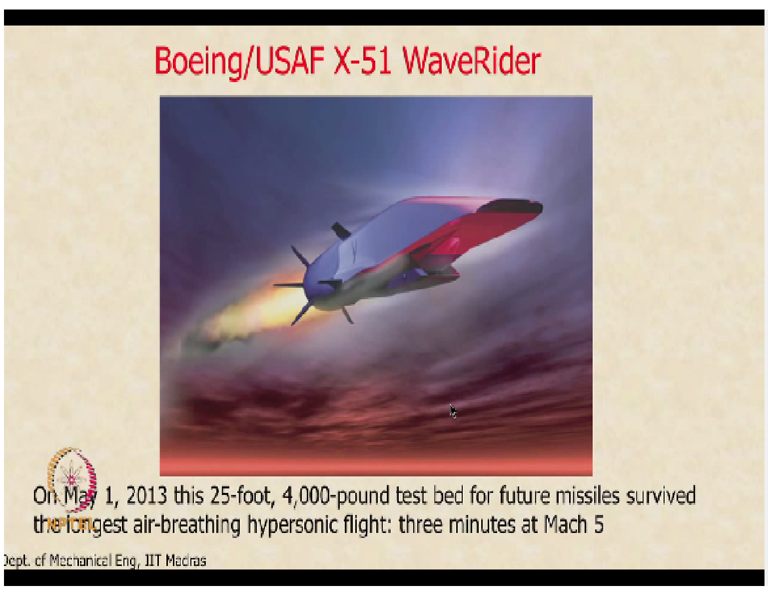

In fact this aircraft, this technology is being tried for nearly 20 to 30 years now, okay. Engineers have been trying to realise this technology for more than 30 years now and only last year, this vehicle that I showed, this is an artist's conception but the vehicle that I showed in this figure, this scramjet vehicle on May 1st, 2013, it actually had sustained the hypersonic flights for only 3 minutes that is the current record for sustained hypersonic flight at Mach 5 for 3 minutes is the current record.

So you can see how far we have come and how far we have to go. So to realise this commercially or even for other purposes, is going to be a tremendous challenge, okay. This is the state of the art today. What we will do is look at some of the challenges that people are trying to overcome. Supposedly this technology, the next internet application for this technology is obviously for missiles.

Because this is a smaller, they are not ready to take passengers or they are not in a stage where that can be used for commercial aviation purposes. So the first technology is to use this for missiles which actually will require only a short amount or small amount of thrust to be produced by the engine and so that is the current application that the people are looking at. But the fact that we have sustained hypersonic flight only for 3 minutes, tells you how challenging this technology is. Despite the fact that this is being, this has been tried for more than 30 years now.

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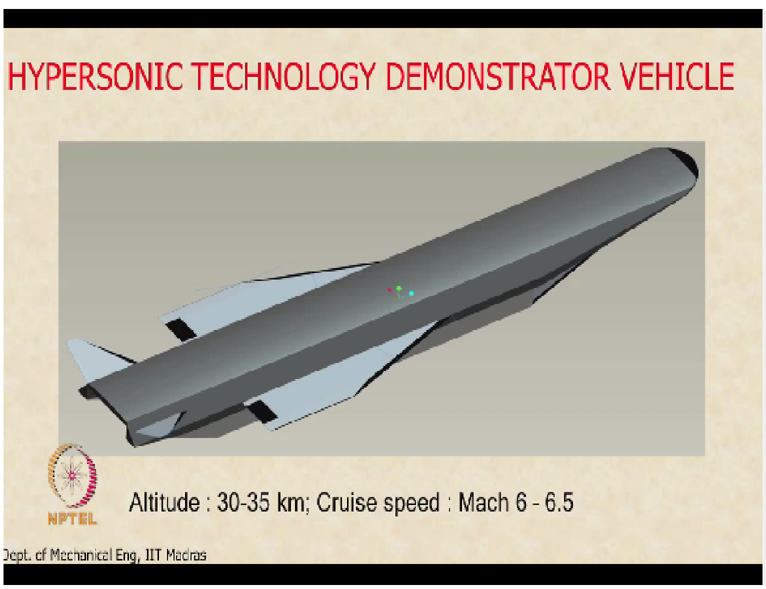

This is what India is trying to develop. This is the hypersonic technology demonstrator vehicle that DRDL has been developing. Hopefully this will be test flown maybe later this year or early part of next year. This is designed for flight Mach number around 6 to 6.5 at altitudes of about 30 to 35, okay. You can see the clean aerodynamics, the single expansion ramp nozzle on this side. You see the intake and fore-body in the intake and then the engine itself here, this is the engine, okay.

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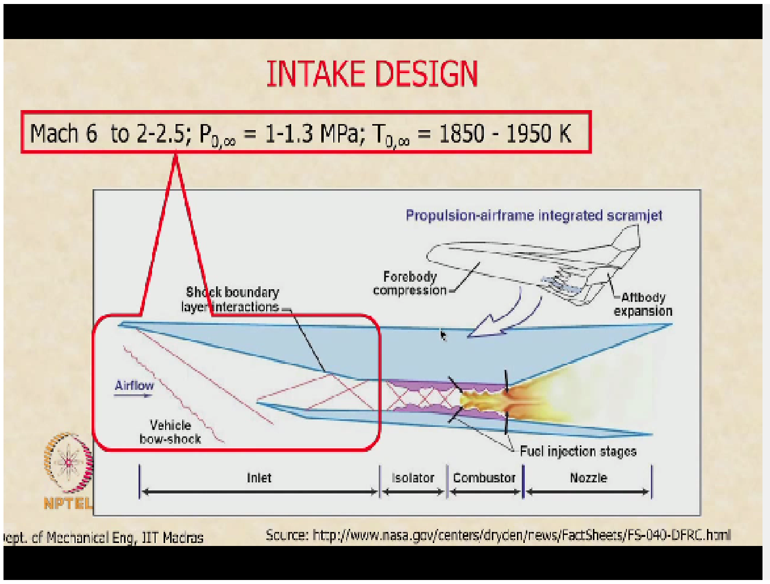

We will talk about differences between the Indian design and the American design as we go along, okay. So here is a nice sketch of the scramjet engine. This engine is what is called a propulsion airframe integrated scramjet. What this means is that the entire body is a lifting body. So the airframe is a lifting body and the engine is actually part of the body, that is why we use the word propulsion airframe integrated.

We can see that the general idea is to have compression on the fore body of the engine which is nicely designed and then expansion against the aftbody of the engine which is also designed properly, so that is an expansion surface and the supersonic flow expands against their expansion surface producing thrust, okay and we can see that you can either have one single engine which develops the entire thrust or we can have a modular approach where you have many such engines, smaller engines which are stacked together, arranged next to each other.

So we can have each module producing a small amount of thrust with some number of modules arranged side-by-side and that is what you are seeing here, okay. Both approaches are feasible, different countries are trying out different things, okay. So a cross-sectional view of this flow path that is shown here looks like this. So we can see the fore-body and the compression of the free stream in the fore-body and then internal compression here through reflected shocks and also passages and then you have a combustor where fuel is injected, combustion and heat release takes place and then you have expansion against the aftbody.

In some cases, the cowl, this component is called a cowl, the cowl may extends up to the end of the nozzle or in some cases, the cowl may be terminated at the end of the combustor, both are possible. Many different, it depends on the aerodynamics of the vehicle. So this is the nozzle and this is the expansion surface. So as the supersonic flow comes like this, then it is made to go like this, you know that that is a convex corner, so the flow will expand against it, so that is what it does.

Notice that in between the inlet and the combustor, we have something new called the isolator. What is the function of this isolator. If you remember, we talked about Rayleigh flow, right. If you add heat in the supersonic flow and remember in this case, the flow entering the combustor is supersonic, right. We said that the Mach number at entry should be around 2 to 2.5. So the flow when it enters the combustor is supersonic and we are trying to add heat.

If the amount of heat that we add, let us say is more than Q* corresponding to this Mach number, then what is likely to happen in this case. You are going to have a normal shock. So if the normal shock occurs and then in this case if the normal shock goes all the way into this intake, then the intake will unstart. The normal shock will propagate all the way here and then it will stand here where it will be very very strong.

So to prevent that from happening, we have this component here called the isolator. The isolator is a constant area duct. It serves no other function but to allow the normal shock to, if in case you have normal shock, to come up and stand here and not go into the, propagate into the intake. So it isolates the combustor and the inlet from each other. So in case the pressure rise due to heat release is too much, okay, that can be a normal shock and the normal shock and the pressure rise will be contained within the isolator and it will not propagate into the intake, that is the function of the isolator. So we can see…

“Professor - student conversation starts” Yes. Normally we make sure that the normal shock will be in the isolator, if you add more heat (()) (41:44) it can again propagate to upstream. Yes, I mean, we remember the isolator is supposed to prevent normal shock from going into the intake for a certain range of operating conditions, okay. So if the normal shock propagates into the intake and the intake unstarts, that is called an inlet interaction or intake interaction, okay.

The isolator is not meant to prevent inlet interaction from happening for all conditions. It is meant to prevent this from happening for a certain range of flight conditions, okay, that is what it is designed to do. Remember as you keep increasing the heat release, the normal shock will keep moving further and further upstream. So we can prevent it from going into the intake for a certain range of, values of heat release, okay but not more than that.

We cannot guarantee that the intake will always be isolated from the combustor, that will not be possible because then you have to increase the length of the isolator and if you increase the length of the isolator, the drag goes up tremendously, the length of the engine goes up and consequently the drag also will go up and we are talking about hypersonic flight Mach numbers, so increase in drag is very detrimental to the performance of the vehicle, yes.

Why to use the constant area duct only, we can use divergent portion also, that will stabilize shock in that portion. There are packaging constraints, okay. Remember this is a propulsion airframe integrated concept, okay. So this surface as you can see from here, this intake surface, combustor surface and this surface is determined by the aerodynamics of the vehicle. So if you want to have enlarged surface here, that will have an effect downstream.

The nozzle will become smaller. So the expansion will also be adversely affected. We can have enlargement but not to the extent, not to a large extent in the isolated itself. In fact, I will show you actual designs later on, the combustor will have such divergences to minimise these types of interaction. It is more effective to put it in the combustor rather than in the isolator, okay. Remember this is propulsion airframe integrated.

So the degree of freedom that we have in changing the underbody of this vehicle is very limited because if you are very aggressive in your expansion, if you take this surface let us say you put a divergence up to here, then the expansion in the nozzle will be reduced by that much, right. This becomes a packaging issue because it is a propulsion airframe integrated device, okay. The engine and the airframe share this common surface which is this surface here. So we are very constrained in what we can do to this surface, okay. **“Professor - student conversation ends”**

So we can see that the intake in this case in contrast to the intake of the ramjet, here we can see that the intake is supposed to decelerate the flow from 6, Mach number 6 to about 2 to 2.5, typically 2, okay and the stagnation pressure, free stream stagnation pressure is in this range about 1 to 1.3 Mpa, free stream stagnation temperature as we can see is already quite high. So we have to be very careful in decelerating this flow.

We do not want to end up with temperatures, static temperatures much higher than what we want in the combustor itself. So we have to be very careful in this deceleration. So the intake itself has to be designed extremely carefully to decelerate such a flow. So the ramp has to be designed very carefully to generate a series of oblique shocks which will decelerate the flow, then some reflections inside plus converging area passage to accomplish the final divergence, final deceleration to Mach 2 or 2.5 before it goes into the isolator, okay.

So the intake is also very crucial in this, just like the ramjet engine. Now the next component is the combustor. Normally when we say combustor in a scramjet engine, we usually mean isolator plus combustor. The isolator is always assumed to be a part of the combustor, okay, that is what we usually mean and as we can see at entry to the combustor, Mach numbers are usually around 2 to 2.5, okay.

Stagnation pressures are only about 0.3 to 0.4. If you remember, previous slide we said stagnation pressure was 1 Mpa. So we can see that in these types of intakes, the stagnation pressure recovery is only about 20% to 30% in the best of situations. For the ramjets, we will have a slightly or not slightly, even better. Ramjet if you remember in our previous calculation, we calculated the pressure recovery, stagnation pressure recovery for the ramjet engine to be around 80%, right.

In this case, typically stagnation pressure recovery will only be between 20% to 30%, no more than 30% in most cases, okay. So stagnation temperature remains the same, there is no energy addition or removal here, so stagnation temperature remains the same but the most challenging aspect in designing the combustor has to do with this. The velocity of the flow as it enters the combustor is of the order of about 1.2 kilometer per second and I showed you the physical scramjet vehicle itself.

You could surmise from that earlier graphic that the combustor itself is only, combustor length is only about 1meter or so, no more than 1 meter. So flow enters the combustor with the speed of 1.2 kilometer per second and within a distance of 1 meter, you must inject the fuel, mix it with the air, get it to ignite, burn, release the heat before it leaves the combustor so that means within a time span of about 1 millisecond.

All these processes must take place, injection, mixing, ignition, completion of combustion in 1 millisecond that proves to be, that continues to prove to be a great challenge in designing the scramjet vehicle. What we will do in the next class is take a closer look at these challenges and what is being attempted now, to address these problems. What are the challenges and what is being done to address these issues that is what we are going to see in the next class.