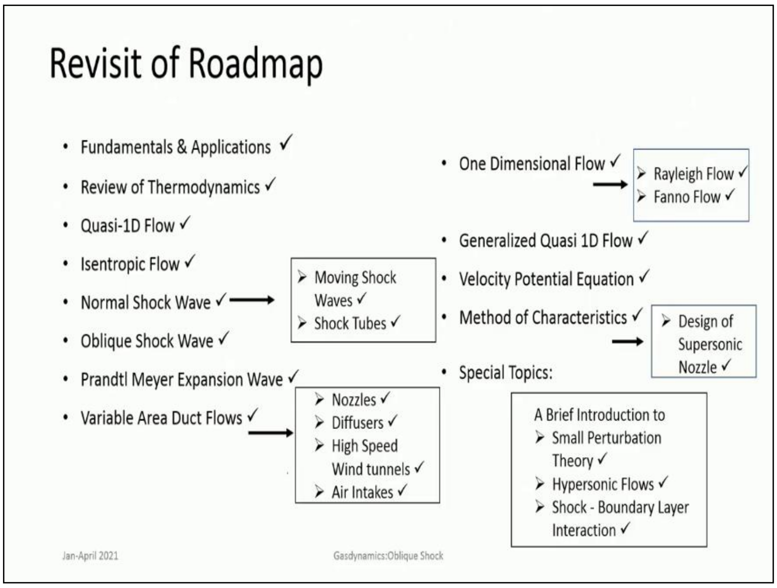
Gasdynamics: Fundamentals And Applications
Prof. Srisha Rao M V
Aerospace Engineering
Indian Institute of Science – Bangalore

Lecture 60
Concluding Remarks

We have come towards the end of our course on gas dynamics fundamentals and applications, and which deals with compressible flow we have covered various topics in this course. So, let us just go back and look at what was the road map that we had set for ourselves at the beginning of this course.

(Refer Slide Time: 00:52)



We wanted to look at compressible flows where an effect of changes in density is very important and we saw that there are different regimes of flow. The speed of sound is a very important parameter and based on speed of sound you have subsonic flows supersonic flows. Flow structures in subsonic flows and supersonic flows are very different Shock waves in supersonic flows.

We looked at mainly the integral approach, quasi-1D flow, control volume analysis. When you consider compressible flows, you cannot separate fluid dynamics from thermodynamics and considerations of temperature and so on. They become coupled to each other. So, we had to go through not only fluid mechanics equations but thermodynamics as well. Then we defined important quantities like stagnation quantities, star quantities in isentropic flows which was a starting point.

To understand the interrelationships of Temperature, Pressure, and Mach number inflows. Then we went into details of shock waves which are always found in supersonic flows where if there is a response to pressure where pressure must increase. Then shock waves may be formed or if a flow must turn towards itself. Then it is accomplished by oblique shocks. We went through equations and applications of normal shocks, moving shocks, shock tubes.

Then looked at oblique shock waves the other part of the story is that shock waves are all compression waves but there may be cases when the flow must turn away out from itself and an expansion may be required. An expansion shock is not possible due to entropy considerations therefore you get a smoother expansion wave which is termed as Prandtl-Meyer expansion wave.

Then we continued the quasi-1D descriptions and went into really good number of details on variable area ducts and its applications in nozzles, diffusers, spin tunnels, air intakes and so on and this involved operation of nozzles how they respond to pressure changes what are their exit conditions, under expanded, over expanded models and so on. While not only changes in area friction as well as heat transfer are important.

We spent some time on Fanno flow and Rayleigh flow which correspond to flow with friction and heat transfer. All these flows consider a quasi-1D assumption where flow properties remain uniform across the flow. But once we have done this and had a good understanding of compressible flows. There was a need to understand that if one must look at flow field details of flow field. Then we must solve differential equations and we looked at inviscid irrotational flow fields.

In that context looked at velocity potential equations and looked at small perturbation theory and then method of characteristics because we saw that the velocity potential equation behaves as an elliptic equation in subsonic flows but behaves as a Hyperbolic equation in supersonic flows. Therefore, in supersonic flows one could use certain methods which are available for hyperbolic equations like method of characteristics.

Using that we looked at how one could design the contour of divergent contour of a supersonic nozzle. So, that smooth flows are produced. That dealt with a major part of compressible flows and thereafter we went into some special topics like hypersonic flows which are high Mach number flows, but certain important physical features become very dominant like high temperature effects, thin chalk layers, thick boundary layers interactions of them and so on.

Then we looked at shock-shock interactions where two oblique shocks of different kinds they interact with each other producing many kinds of flow features. Had a short introduction to real viscous flows in ducts where there are shockwave boundary layer interactions which produce different flow features due to the interaction. So, with this I hope you have got a very good first understanding of gas dynamics compressible flows.

There are lot more things to be learnt and understood in this domain, but the first principle is what we can cover in a course on fundamentals and applications. I hope you have enjoyed this journey until now, thank you.