Turbomachinery Aerodynamics - Video course

COURSE OUTLINE

- **Introduction to Turbomachineries**
- **Axial flow compressors and Fans:** Introduction; Aero-Thermodynamics of flow through an Axial flow Compressor stage; Losses in axial flow compressor stage; Losses and Blade performance estimation; Secondary flows (3-D); Tip leakage flow and scrubbing; Simple three dimensional flow analysis;

  Radial Equilibrium Equation; Design of compressor blades; 2-D blade section design : Airfoil Data; Axial Flow Track Design; Axial compressor characteristics; Multi-staging of compressor characteristics; Transonic Compressors; Shock Structure Models in Transonic Blades; Transonic Compressor Characteristics; 3-D Blade shapes of Rotors and Stators; Instability in Axial Compressors; Loss of Pressure Rise; Loss of Stability Margin; Noise problem in Axial Compressors and Fans
- **Axial flow turbines:** Introduction; Turbine stage; Turbine Blade 2-D (cascade) analysis Work Done; Degree of Reaction; Losses and Efficiency; Flow Passage; Subsonic, transonic and supersonic turbines, Multi-staging of Turbine; Exit flow conditions; Turbine Cooling; Turbine Blade design – Turbine Profiles : Airfoil Data and Profile construction.
- **Centrifugal Compressors:** Introduction; Elements of centrifugal compressor/ fan; Inlet Duct Impeller; Slip factor; Concept of Rothalpy; Modified work done; Incidence and lag angles; Diffuser ; Centrifugal Compressor Characteristics; Surging; Chocking; Rotating stall; Design
- **Radial Turbine:** Introduction; Thermodynamics and Aerodynamics of radial turbines; Radial Turbine Characteristics; Losses and efficiency; Design of radial turbine.
- **Use of CFD for Turbomachinery analysis and design.**

COURSE DETAIL

Sl. No.	Topic/s		Number of Lectures
1	**Introduction to Turbomachineries**	BR & AMP	1
2	**Axial flow compressors and Fans**		17
	Introduction	BR	1
	A simple two dimensional analytical model	AMP	1
	2-D Losses in axial flow compressor stage	AMP	1 Lec + 1 Tute

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http://nptel.iitm.ac.in

Aerospace Engineering

Pre-requisites:

- A full course in **Aerodynamics.**

Additional Reading:

1. Oates Gordon C; Aerothermodynamics of Aircraft Engine Components; AIAA series, 1985.
2. IGTI/ASME; The design of Gas Turbine Engines Thermodynamics and Aerodynamics (chapter 8 and 10), 2005.

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Profile Loss and Blade performance estimation		1
3-D flows in Blade passages		
Secondary flows, Tip leakage flow, Scrubbing	AMP	1
Simple three dimensional flow analysis	AMP	1
Full Radial Equilibrium Equation	BR	1
Free-vortex and other 3-D flow theories	BR	1 Lec + 1 Tute
Axial compressor characteristics		
Single stage characteristics	BR	1
Multi-staging of compressor characteristics		
Multi-spool axial compressor characteristics, LPC, HPC		
Instability in Axial Compressors	AMP	2
Loss of Pressure Rise and efficiency		
Loss of Stability Margin		
Rotating Stall and Surge, Modal and spike disturbance		
Inlet Distortion and Rotating Stall		
Vibrations and Fatigue		
Design of compressor blades	BR	3
2-D blade section design : Airfoil Design – subsonic, transonic and supersonic profiles		
Axial Flow Track Design and Inter-spool duct flow		
Transonic Compressors and Shock Structure models in Transonic Blades		
Transonic Compressor Characteristics		

	3-D Blade shapes of Rotors and Stators in modern compressors		
	Compressor Instability and control	AMP	1
	Noise problem in Axial Compressors and Fans	BR	1
	Solved Examples and Tutorial Problems		2 Tute
3	**Axial flow turbines**		13
	Introduction	BR	1
	Turbine stage	AMP	3 Lec + 1 Tute
	Turbine Blade 2-D (cascade) analysis		
	Work Done, Degree of Reaction, Losses and Efficiency		
	Flow Passage, Exit flow conditions		
	Multi-staging and Multi-spooling of Turbine	AMP	1
	3-D flows in Blade passages		
	Secondary flows, Tip leakage flow & Inter-spool ducts		
	Free-vortex and other 3-D flow theories	BR	1 Lec + 1 Tute
	Turbine Blade Cooling	BR	2
	Turbine Blade design –		
	Turbine Profiles : Airfoil Data and Profile construction	BR	2
	3-D blade shapes	BR	1
	Solved Examples and Tutorial Problems		
4	**Centrifugal Compressors and Radial flow turbines**		8 Lec + 2 Tute
	Centrifugal Compressors	AMP	2 Lec + 1 Tute
	Introduction		
	Elements of centrifugal compressor/ fan		
	Inlet Duct and guide vane, Impeller , Diffuser vanes and vaneless diffusers		

	Slip factor, Concept of Rothalpy, Modified work done		
	Inlet Incidence and Exit lag angles: Impeller and static vanes		
	Centrifugal Compressor Characteristics	AMP	1
	Surging, Chocking, Rotating stall		
	Sources of Centrifugal Compressor Losses		
	Design of Centrifugal Compressors	BR	2
	Design of impellers		
	Design of subsonic and supersonic vaned diffusers, vaneless volutes		
	Radial Turbine	BR	2
	Introduction		
	Thermodynamics and Aerodynamics of radial turbines		
	Radial Turbine Characteristics		
	Losses and efficiency		
	Design of Radial Turbines	BR	1
5	**Use of CFD for Turbomachinery analysis and design**	BR & AMP	4
	Computer aided blade profile generation		
	Cascade Analysis ; Periodicity and boundary conditions		
	3-D blade generation and 3-D flow analysis		
	Flow track and inter-spool duct analysis and design		
	Total : (Including Tutorials)		**44**

References:

1. Nicholas Cumpsty, Compressor Aerodynamics, 2004, Kreiger Publications, USA.
2. Johnson I.A., Bullock R.O. NASA-SP-36, Axial Flow Compressors, 2002 (re-release), NTIS.

3. El-Wakil, M M; Powerplant Technology, 1984, McGraw-Hill Pub.
4. NASA-SP-290, Axial Flow turbines, 2002 (re-release), NTIS, USA.
5. J H Horlock, Axial flow compressors, Butterworths, 1958, UK.
6. J H Horlock, Axial Flow Turbines, Butterworths, 1965, UK.
7. B Lakshminarayana; Fluid Mechanics and Heat Transfer in turbomachineries, 1995, USA.
8. Ahmed F. El-Sayed; Aircraft Propulsion and Gas Turbine Engines; CRC press, 2008.