AERODYNAMIC DESIGN OF AXIAL FLOW COMPRESSORS & FANS

PROF. CHETANKUMAR SURESHBHAI MISTRY

Department of Aerospace Engineering
IIT Kharagpur

PRE-REQUISITES : BE, Having background of Thermodynamics, Gas Dynamics, Gas Turbines, aircraft Propulsion etc.

INTENDED AUDIENCE : UG,PG, PhD scholars, Industry working professionals

INDUSTRY SUPPORT : Indian Air Force, Indian Navy, Indian Army, DRDO, ISRO, NAL,HAL,GTRE and companies such as GE, P&W, R&R, Siemens, MHI etc.

COURSE OUTLINE :

This course builds upon basics of Thermodynamics, Aircraft Propulsion and Gas Dynamics that students have learnt in previous pre-requisite courses and aims to give the students a fundamental understanding of how axial flow compressor and industrial fans work and how they are designed as per specific requirements for land based power plants, aircraft jet engines, special applications in process industries as well as future electric propulsion systems. The aerodynamics and fluid flow aspects of axial flow compressors and fans are covered with considerations of recent advancements in design processes.

ABOUT INSTRUCTOR :

Prof. Chetankumar Sureshbhai Mistry is an Assistant Professor in the Department of Aerospace Engineering, IITKharagpur.He has 19years' experience in teaching and research. He has done his graduation in Mechanical Engineering from REC, Surat (Presently NIT-Surat). He received his Master's of Engineering in Turbo Machinery from NIT, Surat; Ph.D. from IIT Bombay. His Ph.D. thesis on "Experimental Investigation on the Performance of a Contra Rotating Fan Stage under Clean and Distorted Inflow Conditions" awarded with "Award for Excellence in Thesis Work", IIT Bombay in 2014. He is also a recipient of "ASME- IGTI Young Engineer Travel Award" in 2013. His area of research are: design and performance augmentation strategies for turbomachines, experimental and CFD study of turbomachines, contra rotating axial flow turbomachines aerodynamics, electric propulsion as well as fluid mechanics & heat transfer, and experimental aerodynamics.

COURSE PLAN :

Week 1: Introduction to axial flow compressor and fans, applications for aircraft engines, land based power plants, industrial applications, Construction of axial flow compressor, Euler's equation and velocity triangles for axial flow compressor. Concept of diffuser in the view of compressor passage design, understanding of compression process using T-S diagram, Adiabatic efficiency and Polytropic efficiency (Tutorial)

Week 2: Understanding of aerodynamic and thermodynamic work for compression process, axial, radial and tangential momentum , Various fan and compressor possible configurations like Only rotor, Inlet guide vanes (IGV) +rotor, IGV + rotor +stator, Contra rotating stage configurations and their application based on specific requirement, 2D aerodynamics of stage, Introduction to Diffusion factor, Degree of reaction, Dehaller's factor (Tutorial)

Week 3: 3D flow through axial flow compressor, Work done factor, Radial Equilibrium Theory and it's applications, Introduction to various design approaches like Free Vortex, Force Vortex, Constant Reaction, Exponential method, Constant alpha and Fundamental based design approaches for compressor and fan design. (Tutorial)

Week 4: Flow track design and understanding with different requirements, Axial flow compressor cascade and Introduction to various angles like Air angle, Flow angle, Incidence angle, Deviation angle, Camber angle, Stagger angle etc. and their importance in design, Introduction to various cascade tunnels

Week 5: Selection of camber line, Selection of various angle for design consideration and their effects on performance of axial flow machines, Concept of Critical Velocity Ratio. (Tutorial)

Week 6: Criteria for selection of various design parameters, Guidelines for selection initial parameters as first cut calculation, Systematic approach for design of axial flow compressor design based of various approaches.
(Tutorial)

Week 7: Design of low speed axial flow compressor based of various design considerations, Adoption of airfoil geometry for finalizing the rotor and stator blades. (Tutorial)

Week 8: Design of low speed contra rotating axial flow compressor based of various design considerations, Adoption of airfoil geometry for finalizing the rotor blades. (Tutorial)

Week 9: Need for transonic compressor stages, Type of Transonic Airfoils and their special applications, Selection of various blade parameters.

Week 10: Design of Transonic axial flow compressor based of various design considerations. (Tutorial)

Week 11: Need for future axial flow compressors for specific applications and special need. Design of industrial fans based of various design considerations. (Tutorial)

Week 12: Use of CFD for axial flow compressor and fan analysis and understanding of modifications in design, Mesh selection criteria, Boundary conditions, Selection criteria for turbulence models, Selection of various flow domain interface, Post processing approaches, Case studies with various aspects, Issues and Challenges for CFD application to axial flow compressor, Next generation CFD demands