AIRCRAFT PROPULSION
ENAS 303

Lecture : 3 | **Year : III**
Tutorial : 1 | **Part : I**
Practical : 0

Course Objectives:
The objective of this course is to provide knowledge relevant to aircraft engines and aerospace propulsion systems. After completion of this course the students will be able to know in depth knowledge of the design process of propulsion systems.

1 Introduction (2 hours)

- 1.1 Brayton cycle
- 1.2 Types of jet engine
- 1.3 Components of jet engine
- 1.4 Basics of total and static enthalpies
- 1.5 Thrust equations and propulsive efficiencies

2 Fundamentals of Thermal Turbo-Machines (8 hours)

- 2.1 Review on compressible aerodynamics
- 2.2 Turbo-machine system discretization
- 2.3 Fundamental equations
  - 2.3.1 Conservation of mass
  - 2.3.2 Conservation of energy
  - 2.3.3 Conservation of momentum
  - 2.3.4 Euler's turbine equation
  - 2.3.5 Rothalpy
- 2.4 Efficiencies
- 2.5 Isentropic efficiency
- 2.6 Calculating with isentropic efficiencies
- 2.7 Polytropic efficiency

3 Combustion Chambers and Nozzles (8 hours)

- 3.1 Classification of combustion chambers
- 3.2 Important factors affecting combustion chamber design
- 3.3 Combustion process
- 3.4 Combustion chamber performance
- 3.5 Effect of operating variables on performance
  - 3.5.1 Flame tube cooling
  - 3.5.2 Flame stabilization

3.5.3 Use of flame holders
3.6 Theory of flow in isentropic nozzles
3.7 Convergent nozzles and nozzle choking
3.8 Nozzle throat conditions
3.8.1 Nozzle efficiency
3.8.2 Losses in nozzles
3.8.3 Over expanded and under expanded nozzles

4 Inlet and Compressors (10 hours)

4.1 Inlet design and types of compressors
4.2 Stage velocity triangle
4.3 First design parameter: Degree of reaction
4.4 Second design parameter: Loading factor
4.5 Third design parameter: Flow coefficient
4.6 The normalized velocity triangle
4.7 Special cases
4.7.1 Degree of reaction equal to one half
4.7.2 Zero exit swirl
4.8 Simplified off-design analysis
4.9 Axial compressor - Effect of degree of reaction
4.10 Compressor design aspects
4.10.1 Axial compressor rotor types
4.10.2 Multiple rotors
4.10.3 Rotor blade mount
4.10.4 Stator vane mount
4.10.5 Variable stage geometry
4.11 Surge control (Bleed valve)
4.12 Boundary layer control
4.13 Aspiration
4.14 Blade twist

5 Turbines (8 hours)

5.1 Types of turbine
5.2 Stage velocity triangles
5.3 First design parameter: Degree of reaction
5.4 Second design parameters: Loading factor
5.5 Third design parameters: Flow coefficient
5.6 The normalized velocity triangle
5.7 Special cases
5.7.1 Degree of reaction equal to zero
5.7.2 Degree of reaction equal to one-half
5.7.3 Zero exit swirl
5.8 Axial turbine - effects of degree of reaction

5.9 Turbine design aspects
   5.9.1 Disk rotor
   5.9.2 Drum rotor
   5.9.3 Sealing aspects
   5.9.4 Action turbine
   5.9.5 Reaction turbine
   5.9.6 Turbine blade geometry
   5.9.7 Three-dimensional effects
5.10 Design of multistage turbine

6 Losses in Turbo-Machines (6 hours)

6.1 Losses
6.2 Losses in a turbine stage
6.3 Loss coefficients
6.4 Dependency of the efficiency from design parameters
6.5 Reaction turbine
6.6 Action turbine

7 Engine Systems (3 hours)

7.1 Turbine engines
   7.1.1 Construction arrangement and operation of turbojet, turbofan, turbo-shaft and turbo-propeller engines.
   7.1.2 Electronic engine control and fuel metering systems (FADEC)
7.2 Engine indicating systems (EICAS/ECAM)
   7.2.1 EGT/ITT
   7.2.2 Engine speed
   7.2.3 Engine thrust indication
   7.2.4 Oil pressure and temperature
   7.2.5 Fuel pressure, temperature and flow
   7.2.6 Manifold pressure, engine torque and propeller speed
7.3 Starting and ignition system
   7.3.1 Operation of engine start systems and components
   7.3.2 Ignition systems and components
   7.3.3 Maintenance safety requirements

Tutorial (15 hours)

1. Brayton cycle analysis
2. Thrust calculations
3. Component-wise performance calculation
4. Problems related to velocity triangle
5. Off-design performance analysis cases

Assignment

1. Engine on design performance and
2. Compute performance parameters for on design condition
3. Perform zero-dimensional cycle analysis of the whole engine
4. Aircraft engine parts identification

Final Exam

The questions will cover all the chapters in the syllabus. The evaluation scheme will be as indicated in the table below:

Chapters	Hours	Marks distribution*
1 and 7	5	8
2	8	12
3	8	12
4	10	16
5 and 6	14	12
Total	**45**	**60**

* There may be minor deviation in marks distribution.

References

1. Dixon, S.L. (1998). Fluid mechanics and thermodynamics of turbomachinery (Latest Edition). Butterworth-Heinemann.
2. Soderberg, C.R. (1949). Unpublished note. Gas Turbine Laboratory, Massachusetts Institute of Technology.
3. Hill, P.G., Peterson, C.R. (1999). Mechanics and thermodynamics of propulsion (Latest Edition). Addison-Wesley Longman.
4. Cohen, H., Rogers, G.F.C., Saravanamuttoo, H.I.H. (1989). Gas turbine theory (Latest Edition). Longman.
5. Oates, G.C. (1985). Aerothermodynamics of aircraft engine components (Latest Edition). AIAA Education Series.
6. Rolls-Royce. (1983). The jet engine. Rolls-Royce.
7. Mathur, M.L., Sharma, R.P. (1999). Gas turbine, jet and rocket propulsion (Latest Edition). Standard Publishers & Distributors.