DIPARTIMENTO DI INGEGNERIA
MECCANICA E AEROSPAZIALE

SAPIENZA
UNIVERSITÀ DI ROMA

FLUID MACHINERY

MSc Energy Engineering – Proff. Domenico Borello and Giovanni Delibra

Objectives

Methodologies and modeling approaches to study the thermo-fluid dynamics behaviour of fluid machines used in energy conversion systems and energy uses.
Basic design principles and introduction to performance limitations.

Programme

Introduction

Energy conversion and power systems
Thermodynamics of energy systems, First and Second Laws.
Fluid dynamics basics, Eulerian and Lagrangian methods, laminar and turbulent flows.

Dimensional analysis and similitude

Dimensional analysis and performance laws.
Incompressible fluid analysis. Performance characteristics for low speed machines.
Compressible fluid analysis and performance characteristics for high-speed machines.
Specific speed and diameter. Cavitation.

Turbomachinery

Definitions, and working principles. Turbomachinery stage, rotor and stator.
Flow in nozzles, Hugoniot equations. Design of sub-sonic and super-sonic nozzles. Off-design nozzle behavior. Flow in diffusers. Rotor flow, Euler work and velocity diagrams in axial and radial turbomachinery. Enthalpy variation in stators and rotors, stage performance definition, efficiency and specific power. Stage degree of reaction. Stage characteristics, axial and radial turbomachinery (turbines and compressors/pumps).

Compressible flow turbines

Thermodynamics of axial turbine stage. Zero reaction and reaction stages. Ideal and real performance analysis. Steam turbine design, Curtis turbine and R=0.5 turbine stages. Loss in steam turbines. Design of seal systems. Humidity effects in low pressure turbine stages.
Gas turbine design, high-pressure and low-pressure stages. Power modulation in compressible flow turbines.

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Hydraulic turbines

Hydraulic turbine configurations and fields of application. The Pelton turbines. The reaction turbines: the Francis and the Kaplan turbines. Performance and characteristic diagrams. Diffuser duct design. Cavitation in hydraulic turbines.

Centrifugal pumps and compressors

Definitions. Thermodynamic analysis of centrifugal turbomachines. Impeller configurations, performance and characteristic curves. Diffuser configurations and performance. Slip factors. Net suction head definition and control.

Axial pumps, fans and compressors

Stage design with reaction degree. Three-dimensional design methodologies. Airfoil theory for two-dimensional analysis, lift and drag and aerodynamic efficiency. Cascade analysis. Limit aerodynamic phenomena, stall and surge.

Marine Turbines

Exercises

Simple exercises

Development and/or testing of turbomachinery-related software

Text books

Fluid Mechanics and Thermodynamics of Turbomachinery, Dixon S.L. and Hall C.A., Elsevier, 2010.

Lecture notes and addenda.