Fluid Mechanics and Thermodynamics of Turbomachinery [TMA]

Responsable	Niederhäuser Elena-Lavinia
MRU	TIN / EIA-FR
Profils/Options concerné-e-s	TE / Energie thermique TIN / Energie
Contrainte temporelle	Semestre 2
Capacité minimum	5
Capacité maximum	30
Groupe de site	Fribourg

Résumé

The use of turbomachinery for different applications (power generation, industries, transportation, etc) has mushroomed in the last years. Turbomachinery is a challenging and diverse field, with applications in many subsets of the mechanical engineering discipline, including fluid mechanics, combustion and heat transfer, dynamics and vibrations, as well as structural mechanics and materials engineering.This lecture, besides students in many subsets of the mechanical engineering discipline, will also appeal to engineers in the aerospace, global power and other industries who are involved in the design, fabrication, installation and operation of turbomachines.

This lecture will be of use to engineers in industry and technological establishments, especially as advanced reviews are included on many important aspects of turbomachinery. The subject of turbomachinery is in continual review, and while the basics do not change, research can lead to refinements in popular methods, and new data can emerge.

The concept of extracting work from a moving fluid dates at least to the time of Archimede. Water wheels drove some of the early developments of the Industrial Revolution before the age of steam power. By the early 20th century, water power was finding a new lease of life for the generation of electricity, and the design of efficient energy converters - turbines - began to accelerate, laying down the key designs which are still very much in use (in somewhat refined forms) today.

During the 1930s and 50s, a large number of very large hydroelectric schemes were built. With the drive to cut back on CO2 emissions from coal-fired power stations, and uncertainty over the long-term economics of nuclear fission generation, there has been a significant increase in the level of government support available for the development of new renewable energy generation schemes. While it is unlikely that further very large hydro schemes will be built- attitudes to environmental disturbance caused by damming glens have changed since the 50s - there remains significant potential for the development of mini-hydro schemes (under 500kW or so). Mini- and micro-hydro also have very significant potential in appropriate technology applications in developing nations.

The reverse of extracting energy from a moving fluid is to impart energy to the fluid to make it move - the role of the pump or the fan. Pumps may range in size from tiny ?cardiac assist? devices to giant pumps used in offshore oil recovery, covering applications in domestic heating, water supply in between. Fans are most often seen in ventilation systems but are also widespread in industrial processes such as in driving air flows in a coal-fired power station.

Knowledge of the flow processes within turbomachines has increased dramatically resulting in the appearance of new and innovative designs. Some of the long-standing, apparently intractable, problems such as surge and rotating stall have begun to yield to new methods of control. New types of flow machine have made their appearance (e.g. the Wells turbine) and some changes have been performed to established design procedures. Much attention is now being given to blade and flow passage design using computational fluid dynamics (CFD) and this must eventually bring forth further design and flow efficiency improvements.

This lecture will include details of a new method of fan blade design, the determination of the design point efficiency of a turbine stage, sections on centrifugal stresses in turbine blades and blade cooling, control of flow instabilities in axial-flow compressors, design of the Wells turbine, consideration of rothalpy conservation in impellers (and rotors), defining and calculating the optimum efficiency of inward flow turbines and comparison with the nominal design. A number of extensions of existing topics will be included such as updating and extending the treatment and application of diffuser research, effect of prerotation of the flow in centrifugal compressors and the use of backward swept vanes on their performance, also changes in the design philosophy concerning the blading of axial-flow compressors.

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Nevertheless, the course will include a theoretical part and an experimental one. The experimental one will be realized on the test rig available in the laboratory LTE in HEIA-FR, on gas/steam turbines. In parallel, visits to the manufacturers of turbomachines will be organized.

Contenu

Sujet	Temps [%]
Basic Principles;	10
Dimensional Analysis: Similitude	15
Two-dimensional Cascades	10
Axial-flow Turbines: Mean-line Analysis and Design	15
Axial-flow Compressors and Ducted Fans	15
Three-dimensional Flows in Axial Turbomachines	10
Fans and Compressors; Radial Flow Gas Turbines	15
Wind Turbines	10

Connaissances préalables

Base of Fluid Dynamics

Modules pré-requis

Aucun

MAs exclusifs

Aucun

Méthodes d'enseignement

Mode	Périodes d'enseignement	Volume de travail (en heures)
Exposés	14	30
Exercices	14	30
Travaux pratiques	14	30
TOTAL	42	90
Crédits ECTS		3

Évaluation (2017-2018)

Examen écrit : 100%

Langues

	Français	Allemand	Anglais	Italien
Enseignement	x			
Documentation	x		x	
Questions d'examen	x			

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Compétences visées

Gérer le projet	10%
Gérer l'avancement technique	
Gérer les coûts et les délais	
Gérer la communication	
Gérer les risques et les imprévus	
Stimuler l'équipe	
Analyser et spécifier des produits / services	**40%**
Analyser le système (pluridisciplinarité)	
Décomposer le système	
Spécifier le système, y compris concept	
Evaluer les risques	
Planifier	
Développer et réaliser	**30%**
Analyser et spécifier en détail	
Concevoir	
Intégrer (d'autres composants ou produits)	
Modéliser / simuler	
Mesurer / tester / caractériser	
Documenter (rapport)	**20%**
Analyser / critiquer	
Proposer les améliorations	
Tirer les leçons / apprendre	
Documenter	
Disséminer	