**KING SAUD UNIVERSITY**

**COLLEGE OF ENGINEERING**

**MECHANICAL ENGINEERING DEPARTMENT**

**SUBJECT: TURBOMACHINERY [ ME 485]**

**COURSE CONTENTS:**

Basic description of turbomachines and their types; Basic equations as applied to turbomachines; Stage and component efficiency; Performance and analysis of axial pumps, compressors and turbines; Performance and analysis of radial pumps, compressors and turbines; Performance and analysis of wind and hydraulic turbines.

**COURSE PREREQUISITES:**

Thermodynamics; Fluid Mechanics

**BOOKS:**

**TEXT:** **Fluid-Mechanics and Thermodynamics of Turbomachinery, S.L. Dixon and Hall ,ButterWorth Heinmann, 6 th Edition.**

**REFERENCES :**

(1)Design of High Efficiency Turbomachinery and Gas Turbines, Wilson and Korakainitis, Prentice Hall; USA

(2) Turbomachinery; Performance and Analysis; Lewis; Arnold London

**SCHEDULE OF LECTURES**

|  |  |  |
| --- | --- | --- |
| **S.No** | **Description**  | **Number of Lectures** |
| 1 | Basic introduction of Turbomachines | 3 |
| 2 | Relevant Fluid-dynamic and Thermodynamic Background | 4 |
| 3 | Dimensional Analysis as applied to Turbomachines | 4 |
| 4 | Definition and Types of efficiencies as applied to Turbomachines | 4 |
| 5 | Work Transfer in Turbomachines | 3 |
| 6 | Hydraulic Turbines | 3 |
| 7 | Centrifugal Pumps, Pump Systems and Fans | 4 |
| 8 | Centrifugal Compressor | 4 |
| 9 | Axial Turbine | 4 |
| 10 | Axial Compressor and Fans | 3 |
| 11 | Wind Turbine | 3 |

**COURSE OBJECTIVES**

1. To identify various types of incompressible and compressible flow , steam, water and gas turbomachines.
2. To have general understanding of the internal and external details of turbomachines and to know their working.
3. To understand dimensional analysis aspects of incompressible and compressible machines and to use this knowledge to estimate the major dimensions of these turbomachines from the existing similar machines.
4. To understand the performance characteristics of both the turbomachine and its connected flow system and to evaluate the operating points at design and off design situation.
5. To understand the off design aspects of operation of turbomachines.
6. To understand and evaluate cavitational operation of centrifugal pumps.
7. To perform basic fluid dynamic vector analysis of both incompressible and compressible flow machines so s to determine internal flow passages and geometry of blades of the rotor of the turbomachines.

**SUBJECT OUTCOMES**

1. Demonstrate comprehension of the necessary basic principles of fluid mechanics, gas dynamics and thermodynamics as covered in earlier courses.
2. Demonstrate comprehension of continuity, energy (steady flow energy equation), and angular momentum equation and apply these to the basic elements of turbo-machinery.
3. Apply continuity, energy (steady flow energy equation), and angular momentum equation in absolute and relative coordinate systems to determine the mean line performance of turbo-machine elements.
4. Apply performance models to estimate non-ideal performance for design and analysis of turbo-machine elements.
5. Demonstrate and visualize the effect of viscosity, compressibility and other effects on the performance of turbo-machines.
6. Demonstrate apply and visualize the fluid dynamics responsible for the limits of turbo-machinery operation and stability like, stall, surge, cavitation and chocking.
7. Apply the above statements for the design of turbo-machinery elements.

**DETAILED COURSE**

**SECTION (A)**  **FUNDAMENTALS**

**Introduction:**

1. Definition and classification of turbomachinery
2. Major types of turbomachines

**Review of Relevant Background:**

1. Basic assumptions
2. Basic equations of fluid flow
3. Basic Laws of thermodynamics
4. Bernoulli’s equation for compressible and incompressible flows and its use
5. Stagnation and static states in fluid flow systems
6. Ideal gas relations

**Dimensional Analysis for Turbomachines:**

1. Flow coefficient, head coefficient, power coefficient, efficiency, similar pumps, specific speeds, and specific diameter. Cordier curves
2. Characteristic curves, load curves, operating point with special reference to centrifugal pumps and pump systems
3. Operation at different speeds

**Efficiency of Turbomachines:**

1. Different types of efficiencies in hydraulic and thermal turbomachinery components
2. Total to total and total to static efficiency of thermal turbines
3. Polytropic efficiency of thermal turbines and compressors

**Work Transfer in Turbomachines:**

1. Frames of references in turbomachines, absolute and rotating frames of references
2. Derivation of Euler’s equation in different forms
3. Rothalpy equation and Bernoulli’s equation in rotating frame of references
4. Merging of Bernoulli’s equation, Euler’s equation and First law

 **SECTION (B) DETAILED STUDY OF MACHINES**

**Hydraulic Turbines:**

1. Description and classification of Hydraulic Turbines
2. Detailed performance analysis of Pelton Wheel Turbine

**Centrifugal Pumps and Fans:**

1. Components
2. Velocity triangles and slip factor
3. Head developed by a pump
4. Various losses in a pumps and fans
5. Hydraulic and overall efficiency of pumps
6. Cavitation and Cavitation analysis

**Centrifugal Compressor:**

1. Velocity triangles at inlet and exit of the compressor
2. h-s diagram of compressor
3. Total to total pressure ratio
4. Mach numbers in components of a compressor

**Axial- flow Gas Turbine:**

1. Description of turbine stage
2. Performance parameters of a turbine stage
3. Performance analysis of turbine stage
4. Derivation of relations of flow coefficient, stage loading coefficient,
5. Stage pressure ratio and maximum and relative Mach number

**Axial-flow Compressor**

1. Description of compressor stage
2. Performance parameters of a compressor stage
3. Performance analysis of compressor stage
4. Derivation of relations of flow coefficient, stage loading coefficient,
5. Stage pressure ratio and maximum and relative Mach number

**Wind Turbine :**

1. Types of wind turbines
2. Performance parameters of wind turbines
3. Analysis of wind turbines

**Grade Distribution:**

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| --- | --- | --- |
| S.NO | COMPONENT | PERCENTAGE OF MARKS |
| 1 | MID TERM I | 15% |
| 2 | MID TERM II | 15% |
| 3 | TERM PAPER | 5% |
| 4 | ASSIGNMENTS | 15% |
| 5 | LABORATORY | 10% |
| 5 | FINAL EXAMINATION | 40% |
| TOTAL | 100 |