GUJARAT TECHNOLOGICAL UNIVERSITY

BE-7 SEMESTER – OLD PAPER – S22 TO W25 – QUESTION BANK

Subject Name & Code: Turbo Machines - 3171927

Unit 1: Introduction to Turbomachineries

Repeated Questions:

1. Definition and Classification of Turbomachines:

- **Q.** Define a turbomachine and classify different types. **(SUMMER 2022, 3 Marks; WINTER 2024, 3 Marks)**
- **Q.** Differentiate between Turbo machines and Positive Displacement machines. **(WINTER 2022, 3 Marks; SUMMER 2023, 7 Marks)**
- **Q.** Differentiate between Fans, Blowers, and Compressors. **(WINTER 2023; WINTER 2024, 4 Marks; WINTER 2025, 3 Marks)**

2. Dimensionless Parameters and Similarity:

- **Q.** Explain the significance of dimensionless parameters: Flow coefficient, Head coefficient, and Power coefficient. **(SUMMER 2022, 7 Marks; SUMMER 2023 – Syllabus; WINTER 2023)**
- **Q.** What are geometric, kinematic, and dynamic similarities? **(WINTER 2022, 7 Marks; SUMMER 2023, 3 Marks)**

3. Noise in Fans and Blowers:

- **Q.** Discuss noise issues for blowers and fans. **(SUMMER 2022, 3 Marks; WINTER 2023)**

Other Important Questions:

1. Classification and Types of Turbomachines:

- **Q.** Briefly classify turbomachines. **(SUMMER 2022, 4 Marks)**
- **Q.** Define driving and driven types of turbomachines. **(WINTER 2023)**
- **Q.** What are the main differences between incompressible and compressible flow machines? **(WINTER 2025, 4 Marks)**

2. Dimensionless Numbers:

- **Q.** What are Reynolds and Mach number? Write down their expression. **(WINTER 2025, 3 Marks)**

Unit 2: Axial Flow Turbines & Radial Flow Turbines

Repeated Questions:

1. Compounding and Multi-stage Impulse Turbines:

- **Q.** Explain the necessity of compounding in axial flow turbines. Classify and explain multi-stage velocity compounded impulse turbine with a neat sketch. **(SUMMER 2022, 7 Marks; WINTER 2023; WINTER 2024, 7 Marks)**

2. Velocity Triangles, Efficiency and Degree of Reaction:

- **Q.** Draw and explain velocity triangles for an inward flow radial (IFR) turbine. Show that for a 90° IFR turbine, the stage loading coefficient is unity. **(WINTER 2023, 7 Marks; WINTER 2024, 3 Marks)**
- **Q.** Define and explain "total to total efficiency" and "total to static efficiency". **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2024, 4 Marks)**
- **Q.** Define the degree of reaction. Derive an expression for it (for axial or radial machines). **(WINTER 2022, 7 Marks; SUMMER 2023, 4 Marks; WINTER 2024, 3 Marks)**

3. Radial Flow Turbines:

- **Q.** List the aerodynamic losses that occur in a radial turbine stage. **(SUMMER 2022, 4 Marks; WINTER 2022, 4 Marks; SUMMER 2023, 4 Marks)**
- **Q.** Explain stage terminal velocity, stage losses, effect of exhaust diffuser, and degree of reaction in a radial turbine. **(SUMMER 2022, 4 Marks; WINTER 2025, 4 Marks)**
- **Q.** Why are radial gas turbines not suitable for large power applications? **(WINTER 2022, 3 Marks; WINTER 2024, 3 Marks)**

4. Axial Flow Turbines:

- **Q.** Explain blade to gas speed ratio for an axial flow turbine. **(WINTER 2022, 3 Marks; WINTER 2023; WINTER 2025, 7 Marks)**

Other Important Questions:

1. Axial Flow Turbines – Velocity Triangles and Performance:

- **Q.** Draw and explain velocity triangles for a 50% reaction stage. **(SUMMER 2023, 3 Marks)**
- **Q.** Draw superimposed velocity triangles of axial flow turbines with proper notations. **(WINTER 2023, 3 Marks)**
- **Q.** Draw stage velocity triangles at the entry and exit for Axial flow turbines. Discuss stage losses. **(WINTER 2025, 7 Marks)**
- **Q.** What information can you learn from a velocity triangle in an axial flow turbine? **(WINTER 2025)**
- **Q.** How can you use a velocity triangle to analyze the performance of an axial flow turbine stage? **(WINTER 2025 OR)**
- **Q.** Energy flow diagram for the impulse stage of an axial turbine. **(SUMMER 2023, 7 Marks)**

2. Impulse Stage and Compounding:

- **Q.** Explain the condition for maximum utilization factor or blade efficiency for an impulse turbine with equiangular blades. **(SUMMER 2023, 7 Marks)**
- **Q.** Describe the differences between a single impulse stage and a multistage velocity compounded impulse turbine in terms of energy extraction and efficiency. **(WINTER 2025 OR)**
- **Q.** How would you design an axial flow turbine using compounding techniques to achieve higher efficiency? **(WINTER 2025 OR)**

3. Radial Flow Turbines:

- **Q.** Draw a Mollier (h-s) diagram for a radial (90° IFR) turbine. **(WINTER 2024, 4 Marks)**

- **Q.** How would you analyze and compare the performance characteristics of radial flow turbine under varying load conditions? **(WINTER 2025)**

4. Applications, Creep and Blade Cooling:

- **Q.** Give five applications of partial admission turbines. **(SUMMER 2023, 3 Marks)**
- **Q.** What is creep? How does it affect gas turbine operation? List methods of cooling gas turbine blades. **(SUMMER 2023, 7 Marks)**

5. Turbine Numericals:

- **Q.** The data pertaining to an impulse turbine is as follows: Steam velocity = 500 m/s, blade speed = 200 m/s, Exit angle of moving blade = 20°. Neglecting friction, determine: (a) inlet angle of moving blade, (b) exit velocity and direction, (c) work done per kg of steam, (d) axial thrust and power for 5 kg/s, (e) blade efficiency. **(WINTER 2023, 7 Marks)**
- **Q.** A 50% reaction stage axial flow turbine has a mean blade diameter of 0.60 m. The maximum utilization factor is 0.85 and steam flow rate is 12 kg/s. Calculate the inlet and outlet absolute velocities and power developed if the speed is 2500 rpm. **(SUMMER 2022, 7 Marks)**
- **Q.** A ninety-degree IFR turbine stage has data: pressure ratio $p_{o1}/p_3 = 3.5$, exit pressure 1 bar, stagnation inlet temperature 650°C, speed ratio $\sigma = 0.66$, rotor diameter ratio $d_3/d_2 = 0.45$, speed N=16000 rpm, nozzle exit angle $\alpha_2 = 20°$, nozzle efficiency $\eta_N = 0.95$, rotor width at entry $b_2 = 5$ cm. Assume constant meridional velocity and axial exit. Determine: (a) rotor diameter, (b) rotor blade exit air angle, (c) mass-flow rate, (d) hub/tip diameters at exit, (e) power developed, (f) total-to-static efficiency. **(SUMMER 2023, 7 Marks)**

Unit 3: Axial Flow Compressors

Repeated Questions:

1. Working Principle, Velocity Triangles and Energy Flow:

- **Q.** With a suitable sketch, explain the working principle of an axial flow compressor and stage velocity triangles. **(SUMMER 2022, 7 Marks; WINTER 2025 OR)**
- **Q.** Draw and explain the "energy flow diagram" for an axial flow compressor stage. **(SUMMER 2022, 3 Marks; WINTER 2022, 3 Marks; WINTER 2025, 3 Marks OR)**
- **Q.** Draw a sketch of a two-stage axial flow compressor with inlet guide vanes and explain it. **(SUMMER 2022, 4 Marks; SUMMER 2023, 3 Marks; WINTER 2023; WINTER 2025, 3 Marks)**

2. Surging and Compressor Efficiency:

- **Q.** What is surging in axial-flow compressors? What are its effects? **(SUMMER 2023, 4 Marks; WINTER 2025, 4 Marks)**
- **Q.** Plot the h-S diagram for an axial flow compressor and define overall total-to-total isentropic efficiency. **(WINTER 2023; WINTER 2025)**

Other Important Questions:

1. Stage Performance and Degree of Reaction:

- **Q.** Define the Work Done Factor for an axial flow compressor. **(SUMMER 2022, 3 Marks)**
- **Q.** Explain supersonic and transonic stages in an axial flow compressor. **(SUMMER 2022, 4 Marks)**
- **Q.** Obtain an expression for the degree of reaction of an axial flow compressor in terms of rotor blade angles, axial velocity, and blade speed (assuming constant axial velocity). **(WINTER 2022, 7 Marks)**
- **Q.** Show graphically the variation of efficiency with specific speed for an axial flow compressor. **(WINTER 2022, 4 Marks)**

2. Losses, Advantages and Applications:

- **Q.** Explain internal and mechanical losses in an axial flow compressor. **(WINTER 2023)**
- **Q.** List various advantages and disadvantages of an axial flow compressor. **(WINTER 2024, 4 Marks)**
- **Q.** Why are axial flow compressors ideal for constant load applications? **(WINTER 2024, 7 Marks)**

3. Axial Compressor Numericals:

- **Q.** An axial compressor stage has data: Temperature and pressure at entry 300K, 1.0 bar, Degree of reaction 50%, Mean blade ring diameter 36 cm, Rotational speed 18000 rpm, Blade height at entry 6 cm, Air angles at rotor and stator exit 25°, Axial velocity 180m/s, Work-done factor 0.88, Stage efficiency 85%, Mechanical efficiency 96.7%. Determine: (a) Air angles at rotor and stator entry, (b) mass flow rate, (c) power required, (d) loading coefficient, (e) pressure ratio. **(SUMMER 2023, 7 Marks)**
- **Q.** An axial flow compressor draws air at 20°C and delivers it at 50°C. Assuming 50% reaction, calculate the velocity of flow if blade velocity is 100 m/s. With work factor 0.85 and angles a=10°, b=40°, calculate the number of stages. **(SUMMER 2022, 7 Marks)**
- **Q.** The following data refers to an axial flow compressor: Relative flow angle at inlet, $\beta_1 = 60°$, turning angle = 30°, ΔC_w = 100 m/s, degree of reaction 50%, speed 36000 rpm, mean diameter = 140 mm, inlet pressure = 2 bar, inlet temperature = 57°C. Find air flow angle α_1, pressure rise, mass flow rate (blade height=20mm), and power. **(WINTER 2023, 7 Marks)**
- **Q.** A multistage axial compressor is required for compressing air at 293 K through a pressure ratio of 5 to 1. Each stage is to be 50% reaction and the mean blade speed 275 m/s, flow coefficient 0.5, and stage loading factor 0.3, are taken, for simplicity, as constant for all stages. Determine

the flow angles and the number of stages required if the stage efficiency is 88.8%. Take Cp = 1.005 kJ/(kg°C) and γ = 1.4 for air. **(WINTER 2025)**

Unit 4: Centrifugal Compressors

Repeated Questions:

1. Slip and Slip Factor:

- **Q.** Explain the phenomenon of slip in centrifugal compressors and the significance of the slip factor in deciding the number of vanes. **(SUMMER 2022, 7 Marks; WINTER 2022, 7 Marks; WINTER 2023, 7 Marks; WINTER 2024, 7 Marks; WINTER 2025, 7 Marks OR)**

2. Construction, Diffusers and Losses:

- **Q.** Describe the principle, construction, and working of a centrifugal compressor with a sketch showing principal parts. **(SUMMER 2022, 4 Marks; WINTER 2024, 3 Marks; WINTER 2024, 4 Marks)**
- **Q.** What is the function of a diffuser? Explain vaneless and vaned diffusers used in centrifugal compressors. **(SUMMER 2022, 4 Marks; WINTER 2023; WINTER 2025, 3 Marks OR)**
- **Q.** List and explain the different types of losses in a centrifugal compressor. **(SUMMER 2022, 3 Marks; WINTER 2023; WINTER 2025, 4 Marks OR; WINTER 2025, 3 Marks)**

Other Important Questions:

1. Performance and Blade Angles:

- **Q.** Explain the influence of inlet and outlet blade angles on the performance of a centrifugal compressor. **(SUMMER 2022, 3 Marks)**
- **Q.** Discuss the general (Ideal) characteristics of a centrifugal compressor. **(WINTER 2023)**

2. Slip, Inlet Guide Vanes and Inducer:

- **Q.** Show slip and velocity distribution using the velocity triangle of a centrifugal compressor. **(WINTER 2023)**
- **Q.** What is the purpose of inlet guide vanes and inducer blades in a centrifugal compressor? **(WINTER 2022, 4 Marks)**
- **Q.** What is a no-slip condition? Define slip factor. **(WINTER 2024, 3 Marks)**

3. Centrifugal Compressor Numericals:

- **Q.** Determine the pressure ratio developed and the power required to drive a centrifugal air compressor (impeller diameter = 45 cm) running at 7200 rpm. Take zero swirl at entry and T_{01} = 288 K. Assume isentropic flow, no shock, and radially tipped impeller blades. **(SUMMER 2023, 7 Marks)**
- **Q.** A centrifugal compressor running at 1440 rpm handles air at 101 kPa and 20°C and compresses it to a pressure of 6 bar isentropically. The inner and outer diameters of the impeller are 14 cm and 25 cm. The inlet blade width is 2.5 cm. Blade angles are 16° and 40° at entry and exit. Calculate mass flow rate, degree of reaction, power input, and blade width at outlet. **(SUMMER 2022, 7 Marks)**
- **Q.** A centrifugal compressor raises the static pressure of air by 14cm of water while running at 650 RPM and consuming 85 metric HP. Intake conditions: P=75 cm of Hg, T=25°C. Mass flow rate is 260 kg/min. Find the exit static pressure and the volume flow rate in m^3/min. **(WINTER 2024, 7 Marks)**

Unit 5: Fans and Blowers

Repeated Questions:

1. Flow Analysis and Volumetric Efficiency:

- **Q.** Explain in detail about the flow analysis in impeller blades, volute, and diffusers in fans and blowers. **(SUMMER 2022, 7 Marks; WINTER 2022, 4 Marks; WINTER 2025, 7 Marks OR)**
- **Q.** Explain the volumetric efficiency of fans and blowers. What factors govern it? **(SUMMER 2022, 3 Marks; WINTER 2022, 7 Marks; WINTER 2023; WINTER 2025, 7 Marks; WINTER 2025, 4 Marks OR)**

2. Classification and Types of Fans:

- **Q.** State the types of Centrifugal Fans. Explain any one briefly. **(SUMMER 2022, 4 Marks; SUMMER 2023, 4 Marks)**
- **Q.** Classify fans and blowers. **(WINTER 2023, 3 Marks; WINTER 2024; WINTER 2025, 4 Marks)**

3. Losses and Noise:

- **Q.** List and explain different losses in fans. **(SUMMER 2022, 3 Marks; WINTER 2023, 4 Marks)**
- **Q.** Explain noise problems in fans and blowers. **(SUMMER 2022, 3 Marks; WINTER 2024, 3 Marks)**

Other Important Questions:

1. Fan Efficiencies and Characteristics:

- **Q.** Define for fans: Static efficiency, Total efficiency, and Volumetric efficiency. **(WINTER 2023, 3 Marks)**
- **Q.** Draw and explain the performance characteristics (Pressure coefficient vs. Flow coefficient) for different types of centrifugal impellers. **(WINTER 2022, 7 Marks)**
- **Q.** Explain theoretical and actual characteristics of a centrifugal fan. **(WINTER 2023, 4 Marks)**

2. Axial Fans:

- **Q.** List methods to reduce surging in axial fans. **(WINTER 2024, 3 Marks)**
- **Q.** Draw a sketch of an axial flow ducted fan without guide vanes and highlight its parts. **(WINTER 2024, 4 Marks)**

Unit 6: Use of CFD for Turbo machinery Analysis and Design

Repeated Questions:

1. CFD for Turbomachinery:

- **Q.** What is the use of CFD for Turbo machinery analysis and design? Explain its application in detail. **(WINTER 2022, 3 Marks; WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**
- **Q.** Explain the advantages, disadvantages, and limitations of CFD from a turbomachinery point of view. **(WINTER 2023, 7 Marks; WINTER 2024, 7 Marks)**

Other Important Questions:

None identified.

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