Project Description

Overview and guidelines

Objective

To design a **highly efficient, light and compact** transonic fan for aero-engines

- ✓ Maximize η_{tt}
- ✓ Minimize frontal area
- ✓ Minimize weight (blade count, chord, etc.)

[Courtesy of RR]

Design Specs Aero-engine Fan

- Design Conditions:
  - Cruise altitude = 10km
  - Cruise Mach = 0.78

- Design total to total pressure ratio: $\boldsymbol{\beta_{tt} = 1.6, consider\ range\ 1.4 - 1.7}$

- Design mass flow rate: $80\ \boldsymbol{kg/s}$

- Rotational speed: 5000 $\boldsymbol{rpm}$ **(based on axial inflow Mach of 0.6, relative tip Mach number 1.4, hub-to-tip ratio 0.3)**

Rules of Engagement for the Project

1. This is a group assignment. The ideal number of group members is **3/4**. Groups of **max 4 people** are allowed.

2. The final "product" is a **poster** (example on BS), displaying the compressor specs and relevant data.

3. The poster must contain the following:

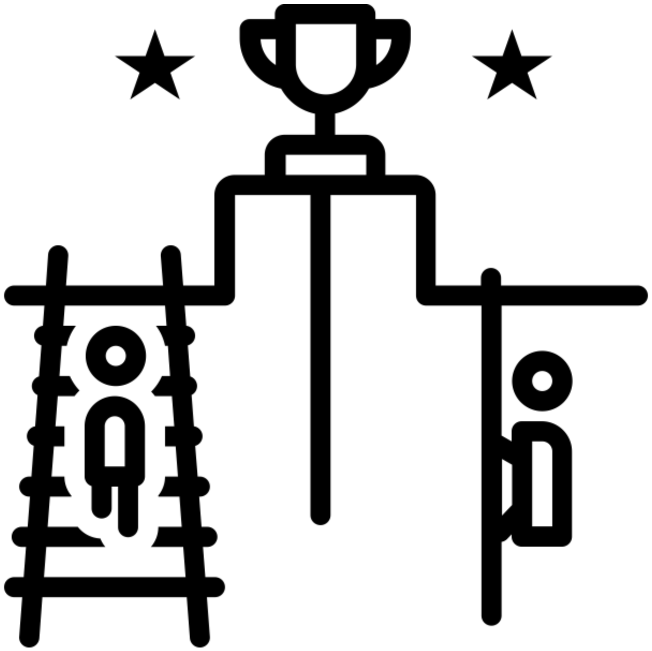
   - Problem statement
   - Design procedure → **see later**
   - Layout of the turbomachine → **see later**
   - CFD analysis of the turbomachine → **see later**
   - Conclusions & recommendations → **see later**

Rules of Engagement for the Assignment

4. The due date for the delivery is **24/04/2024**. All groups present their poster to the other groups and each group presents their work to us.

5. **This is also a design competition!**

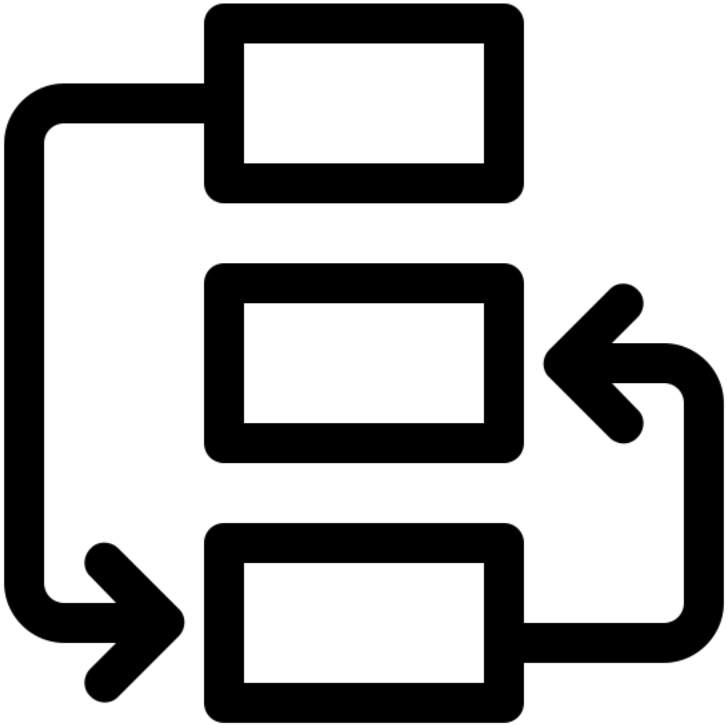
6. Winner group is given **1 bonus point** and granted the possibility to 3D print a scaled model of compressor



Design Procedure -1: Deliverables

a) Block diagram showing the design procedure

b) Concise description of the block diagram

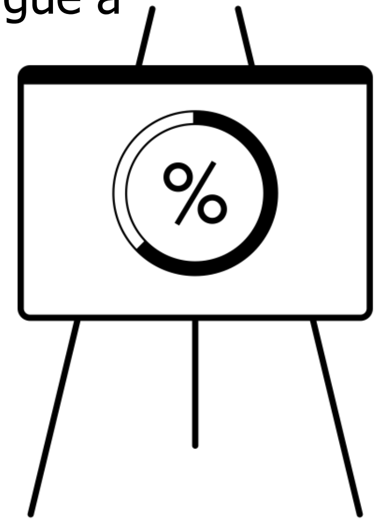


Design Procedure -2 : Deliverables

c) In case of design optimization, explain objective function(s), constraint(s) and optimization workflow.

d) In case of multi-objective optimization:

- Defend your approach (Pareto front, cost function…)
- Show final point and motivate choice.
- No numerical optimization required! You can also argue a parametric study.



Meanline Design: Deliverables

1. Stage size and duty coefficients
2. Schematic of meridional flow path and velocity triangles
3. Thermodynamic (total/static) and flow properties at all stations
4. Stage efficiency (total-to-total and total-to-static) and power
5. Aerodynamic and centrifugal forces
6. Loss coefficients for rotor and stator

Suggestion on the procedure to follow

1. start with isentropic design
2. calculate loss coefficients using a loss model
3. update compressor design

CFD Analysis: Deliverables

1. Stage performance parameters → power, mass flow rate, polytropic efficiency, duty coefficients
2. Cascade performance parameters → rotor/stator loss coefficients at hub, mid, and tip
3. Contour of Mach number and dimensionless pressure distribution along the blade surface at mid-span

Ultimate goal of CFD analysis → meet the requirements in terms of design point operating conditions

Conclusions: Expectations

- 3 to 4 bullet points
- Compare meanline and CFD results in terms of power output, mass flow rate, fluid-dynamic performance and comment
- Provide recommendations on how to improve the fan design based on the obtained results → **be specific** (why and why not). Generic statements like "carry out shape optimization" or "run 3D CFD of full machine" will not be considered as recommendation and will lead to a penalization of the grade!
- Be concise!