Final Design Project

Report and Presentation Due: Monday, April 30th 6:00 pm

1 Overview

You have been asked to design the compressor stage for a new type of gas turbofan engine. The compressor will be used to increase the density of intake air before it is fed into a combustor and turbine. Your goal is to design and optimize the efficiency of the compressor stage using CFD as a tool. Simulations can be used to optimize and find the optimal:

- Geometry of the compressor rotors
- Rotor speed

The primary driver of your design will be to minimize the power required to operate the compressor in the operating envelope described below.

2 Performance Requirements

Your compressor design will drive the design of the rest of the engine. The customer has mandated the following requirements for the design:

- The compressor shall provide a minimum pressure ratio of 20:1 at maximum design altitude. The compressor can work as a single or multistage unit.
- The engine is being designed to work at a maximum altitude of 37,000'. However the customer would also like to know the maximum pressure ratio at sea level (STP conditions) at design speed.
- The outer diameter of the compressor should be between 4' and 6'. This includes all of the parts required by your design.
- The maximum operating speed of any stage should be less than 65,000 rpm. If a multistage compressor is used, each stage may operate at a different speed as long as you explain how this would work.

2.1 Assumptions

- For the purposes of simulating your engines performance, you may assume the engine is tested on a test stand and that the entrance condition is operated at subsonic speeds.
- The air entering the engine may be assumed to be at standard conditions for the specific altitude being analyzed.
- The exit condition for the compressor stage is to be an exhaust tube matching the exit diameter of the final stage of your compressor.

3 Project Requirements

The project's design criteria are multifaceted. They include the following:

- Meeting the design performance requirements and limit specifications.
- Use the minimum power required to achieve the requirements

- All work should be reported in I-P units.

3.1 Items of non-responsibility

You will not be responsible for engineering the following beyond common sense assumptions:

- Strength of parts
- Material compatibility / costs
- Manufacturing methods / costs

4 Deliverables

Your design needs to be presented in several ways and needs to fully convey the manner in which it works. The items should include the following:

4.1 Final Report

The report should be typed and submitted on time by the final delivery date. Your report should be of a professional level meeting the standards discussed in class. In general color or black and white images are acceptable as long as they are legible and clearly demonstrate the results.

The report will be graded based on the hardcopy submitted; in addition you are required to submit an electronic PDF copy. Late documents will not be accepted.

Your report should include:

- Design assumptions.
- Statement of design concept.
- Scaled sketches illustrating the conceptual design.
- CFD simulation images that demonstrate the following:
    - The compression ratio of the device (per stage or compositely) at each altitude at design speed.
    - The simulated entrance and exit temperatures for the air as well as the temperature distribution of the air through the device.
    - The pressure increase of the air at maximum operating altitude through the device
    - Velocity / streamline plots that demonstrate the flow patterns through the compressor stages at maximum operating altitude
- Hand verification calculations for the major elements of your design, including but not limited to:
    - Approximations for entrance and exit temperatures for the air based on fluid and thermodynamic theory
    - Approximations for operating efficiency, i.e. input power to compression ratio
- List the operating conditions of your design at the design altitude, including:
    - Compression ratio
    - Number of stages
    - Operating speed of each stage
    - Power usage at maximum operating speed at each altitude
- Overall size of the unit, length and diameter

- Design time estimate, cumulative number of hours spend developing your design

4.2 Final Presentation (8 minutes)

Your final presentation should provide the audience with an overall summary of your design and the key analyses that were used to arrive at it. This should include:

- The design concept
- Your compressor performance, i.e. pressure ratios, operating parameters, efficiency, size, etc.
- How CFD simulations helped influence your design
- Design time estimate
- Design benefits.

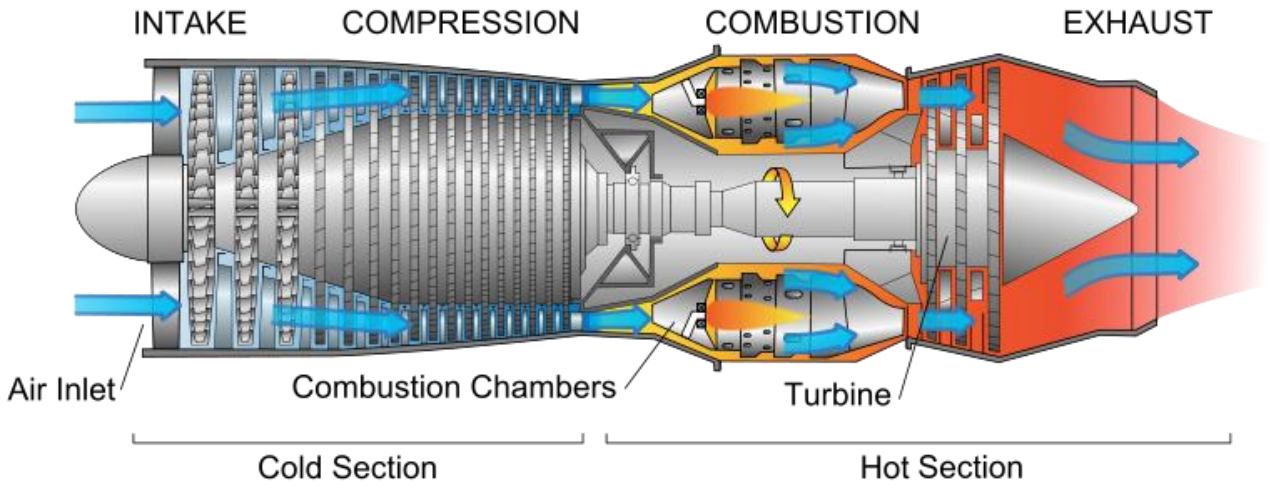
5 Suggestions

The following is a list of suggestions that may be helpful in getting a jump start on your design submission.

5.1 Starting points

There are many resources out there for how jet engines work. Use them to get a basic idea as to who you want to design your system.

5.1.1 Basic jet engine design



http://en.wikipedia.org/wiki/Axial_compressor

5.1.2 Atmosphere properties

http://en.wikipedia.org/wiki/Atmospheric_pressure