A hands-on gas turbine technical design and development perspective

Or

Experiencing the real-life challenges of a gas turbine engineer

PROJECT BACKGROUND

You are a junior gas turbine design engineer in **ACME's Gas Turbine A.D.C.I.** group (**A**dvanced **D**esign & **C**ompetitive **I**ntelligence). The Product Development Manager has tasked you to design and analyze the following gas turbine engine component:

Turbo-Fan → Fan Stage

The purpose of this work is to prepare the foundation for the extended company functions to develop a competitive product. To do so, you will:

- Use the **MDIDS-GT** design software, with the given engine & component data, to:
  - create the 1D mean-line model of the Fan stage with the configuration as shown in Figure 1 and listed below:
    - rotor
    - core stator
    - bypass (split) stator
    - bypass strut
  - design the fan stage airfoils with preliminary stress analysis results
  - design the fan stage disk with preliminary stress analysis results
- Predict the Fan stage performance characteristics, and describe its various design features

PROJECT DETAILS

This project is based on **individual effort**. It is divided into **4** parts.

1) Preliminary / conceptual turbofan engine cross-section set-up
2) Fan stage 1D mean-line model based design and analysis
3) Fan stage airfoil designs with preliminary stress analysis
4) Fan stage disk design with preliminary stress analysis

Electronically submitted report

The project will be submitted electronically, by the specified deadline date, for review and grading. The format of the report will follow a general report format of your choosing. This report should include, but is not limited to:

- Title page
- A picture of the engine cross section
- A series of pictures of the stage airfoils and disks
- The various engine facts and data (tabular, bullet point, quotes, etc)
- A reference list of where you obtained any additional data
- A discussion of the data, graphs, and models
- A conclusion

NOTES:

- The language should be in the third person; French or English
- In your discussions and/or conclusions, state your assumptions and supporting information
- Do not over discuss the available data
- There is no maximum number of pages imposed for the document, it depends on your efforts
- Consolidate, as best as possible, the data into tables, graphs, and pictures

The final mark for the report will be based on the quality of the report presentation, the richness of the discussions, the insight of your conclusions, and what lessons you have learned from the project.

STEP 1: Preliminary Sizing & Performance Analysis

Preliminary Definition	Data
Number of Spools	2
Combustor Type	Straight through
Engine Type	Turbo-Fan
Engine Size	None
Exhaust	unmixed
Cycle	Open Cycle

Design Criteria	Data
Altitude	0
+Δ	0
Target Thrust [lbf]	9317
BPR (ByPass ratio)	5.0
Core mass flow [lbm/s]	45
Forward Mach number	0.0

Boundary Conditions	Data
Comp. Inlet Angle	0
Turbine T4 [Rankine]	2250
Delta T	0
Combustor eta	1
Pressure Loss	0
Turb. Inlet Angle	0

Fan Stage	Data
Stages	1
Spool RPM	7500
Compressor Work [BTU/lbm]	10
Efficiency	1.0

Compressor Spool 2	Data
Stages	0

Compressor Spool 1	Data
Stages	14
Spool RPM	15000
Compressor Work [BTU/lbm]	170
Efficiency	1.0

Turbine Spool 1	Data
Stages	2
Efficiency	1

Turbine Spool 2	Data
Stages	3
Efficiency	1

Resultant Engine Performance	Data
Total Thrust [lbf]	9317.6
Bypass Thrust %	63.735
TSFC [lbm / (hr lbf)]	0.318
(OPR) Overall pressure ratio	22.905
f/A (fuel to air ratio)	0.018
Fuel [lbm/s]	0.823

Exhaust Design Data

Bypass Duct Geometry	Data
Ax Length	35
Segment No.	1

Core Duct Geometry	Data
Ax Length	25
Segment No.	1

STEP 2 (Stage): Fan Stage 1D Mean-Line Data (Spool 1 must be selected)

Parameter	Data
Fan Airfoil Corner Points [inches]	Tip (max) 25 Hub (min) 10
Airfoil Types (for all)	DCA 6%

Has Strut	True
Strut hub radius [inches]	(Preliminary) 18
Bypass Strut	True

Has Split Stator	True
Split Stator tip radius [inches]	(preliminary) 25
Fan Bypass reaction	<= 95

Fan stage work	Refer to prelim engine data Or you may change it to between 10 to 25 [BTU/lbm]
Fan Core Reaction	<= 95

Rotor clearance type	unshrouded
Rotor clearance [inches]	0.02 to 0.05

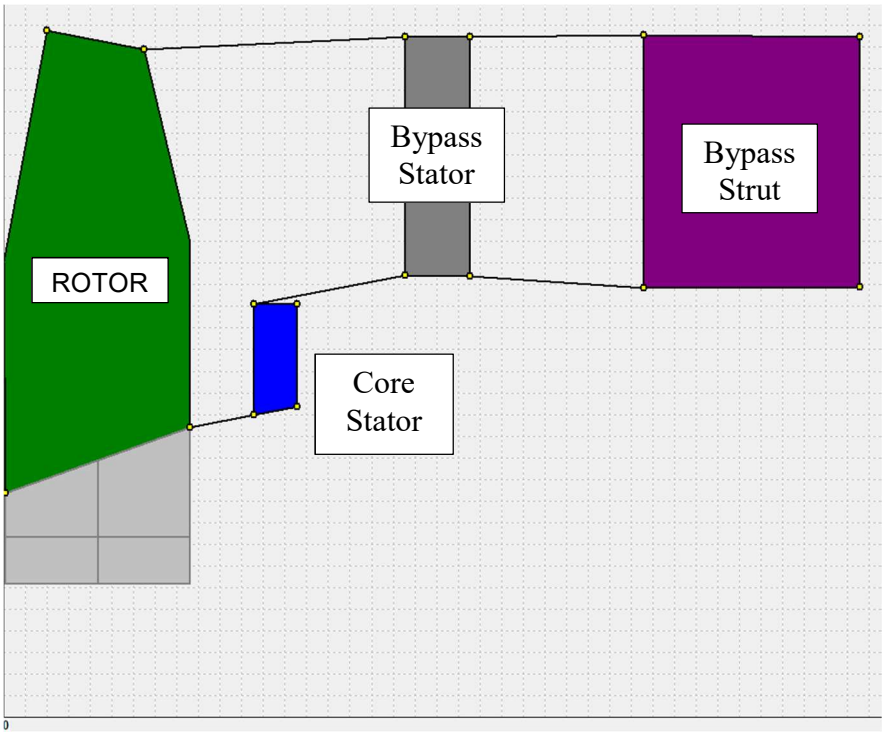

Figure 1: Turbofan stage target layout

Fan Stage Mean-Line Design

Using the developed engine cross section in **MDIDS-GT**, you will further detail the fan stage by executing the 1D mean-line model. Your target, **highest possible stage efficiency**. You will change and report, as a minimum, the following:

- The airfoil corner points
- The airfoil count (number of)
- The reaction values
- The clearance values
- The resultant values of
    - Stage inlet and exit temperatures, pressures,
    - mass flows,
    - stage efficiencies
    - loss structure values
- A sensitivity analysis for those parameters that you have varied to converge to the highest possible efficiency
- Discussion of the results

STEP 2 (Airfoil): Fan Stage Airfoil Design (Spool 1 must be selected)

Using **MDIDS-GT** you will design the fan airfoils:

- should pass the preliminary stress analysis
- be as (relatively) light as possible

Minimum information to be included in the report:

- State all assumptions and guesses for missing information
- A screen shot of the final airfoil geometry, 2D and 3D
- Screen shots of the preliminary stress analysis

Parameter	Data
Airfoil Type	As defined in Step 2 (Stage)
Material	TI-6AL-4V
All other parameters	As-is

STEP 2 (Disk): Fan Stage Disk Design (Spool 1 must be selected)

Using **MDIDS-GT** you will design and compare two (2) fan disk designs:

- should pass the preliminary stress analysis
- be as (relatively) light as possible

Minimum information to be included in the report:

- State all assumptions and guesses for missing information
- A screen shot of the final disk geometry, 2D and 3D
- Screen shots of the preliminary stress analysis

Parameter	Data
Material	TI-6AL-4V
Disk Type	Ring and Web
Fixed bore	Unchecked (not selected)

Disk BC	Data
Rim Ave Ts	Equivalent to mean-line TS values (highest)
Bore Ave Tcool	Equivalent to **Rim Ave Ts**

END OF DOCUMENT