ME343 - Thermal Fluid Systems
Spring 2011, Semester Project Phase 1
Analysis of Westinghouse Model 251B Combustion Turbine
Phase 1 Memo is due March 9, 2011

Overview

The University of Texas cogeneration power plant houses a Westinghouse Model 251B combustion turbine-generator system for electric power generation and a Henry Vogt waste-heat recovery boiler for cogeneration of steam. In your term project, you will develop a computer model to predict and confirm performance of the combustion turbine unit under various operating conditions including the performance effects of evaporative cooling of inlet air and backpressure effects of the waste-heat recovery unit. Your model must be flexible enough to incorporate changes in design parameters (e.g., turbine inlet temperature and inlet airflow) and will be used to perform base case analyses of the W251B system. Figure 1 shows the overall system components and the thermodynamic station numbers for the W251B.

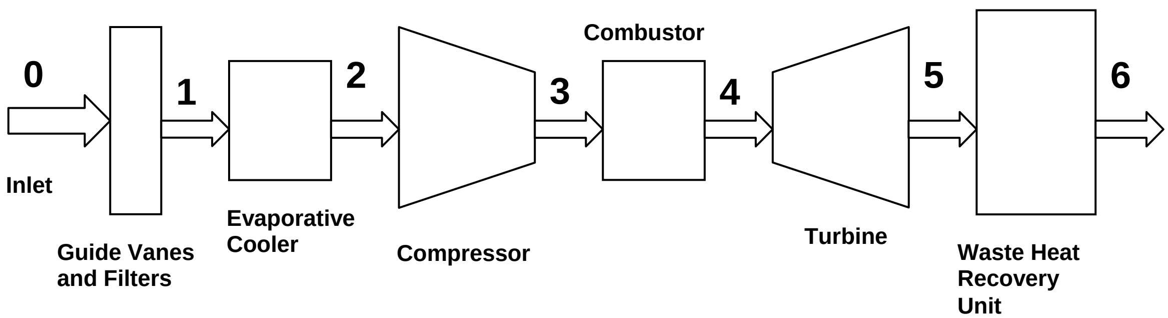

Figure 1: Westinghouse W251B thermodynamic station designations

Phase 1: A Simplified System

In Phase 1 of the project you will perform an air standard Brayton Cycle analysis of a simplified version of the W251B. In this simplified system you will only take into account the compressor, combustor and the turbine. Moreover, the combustor will be modeled as a heat exchanger receiving heat energy equal to the product of the mass flow rate and the Lower Heating Value (LHV) of the fuel. Figure 2 shows the system components of the simplified system to be used in Phase 1 and the associated thermodynamic station numbers.

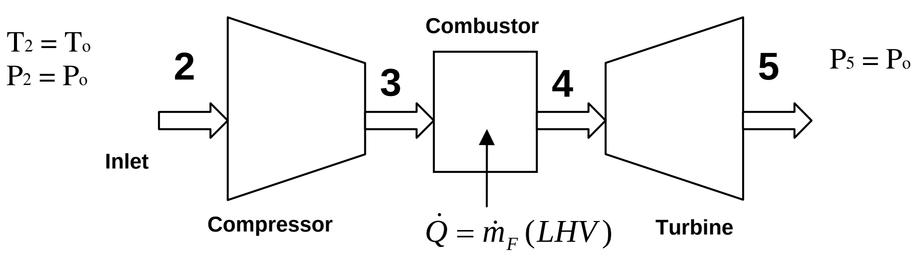

Figure 2: Simplified system for phase 1 and the thermodynamic station

ME343 - Thermal Fluid Systems
Spring 2011, Team Project Phase #1
Specifications for <u>Phase 1 Model</u> of Westinghouse 251B Gas Turbine

General specifications/assumptions:

- Model based on air standard Brayton cycle
- Programming language: Matlab
- Working fluid: pure air (21% O_2, 79% N_2 by volume, relative humidity = 0%)
- Thermodynamic properties: assume ideal gas, non-constant (temperature dependent) specific heats using polynomial functions employed in earlier Matlab Property Calculator model. Modify Property Calculator such that $T_{ref} = 25^oC$, P_{ref} = 1 atm.
- Units: English units for all inputs, SI for all computations, English and SI for all outputs

Input operating parameters

- Base air inlet conditions: P_0, T_0, RH_0, **14.7 psi, 59ºF, 0%**
- Inlet flow rate: $\dot{V}_{IN}$ **290,000 scfm (dry air, 68ºF, 1 std atm ref.)**
- Fuel type and lower heating value: FUEL, LHV, **natural gas, 20,960 BTU/lbm**
- Vary fuel mass flow rate $\dot{m}_F$ (lb_m/hr) to achieve loads from <u>20% to 100% of the full load of 48 MWe (Mega Watt electric)</u>

Input design parameters

- Compressor pressure ratio: r_P **15:1**
- Compressor efficiency: **86.6%**
- Turbine efficiency: **88.5%**
- Generator (Dynamo) efficiency: η_{GEN} **98.5%**

Output performance parameters (to be plotted versus percent of full load)

- Thermal efficiency: η_{TH}
- Fuel mass flow rate $\dot{m}_F$ (lb_m/hr)
- Specfic fuel consumption: SFC (lb_m/kW-hr)
- Heat rate: HR, (BTU/kW-hr)
- Firing (turbine inlet) temperature: T_4 (K and ºF)

Output engine operating conditions

- Temperature and pressure at each major thermodynamic station (create table vs. % load)

ME343 - Thermal-Fluid Systems – Spring 2011
Project Phase #1 Grading Guideline

Memo length: 2 pages text maximum, plus plots of Phase 1 results, plus hand calculations, plus Matlab script

Name:____Total:_______/45____

_______(5) Memo: Introduction and description of assignment

_______(5) Memo: Summary of the hand calculation results: temperature at station 4, component power outputs/inputs and thermal efficiency for full load condition.

______(10) Memo: Plots of Phase 1 results versus percentage of full load:

- Thermal efficiency: η_{TH}
- Fuel mass flow rate $\dot{m}_F$ (lb_m/hr)
- Specfic fuel consumption: SFC (lb_m/kW-hr)
- Heat rate: HR, (BTU/kW-hr)
- Firing (turbine inlet) temperature: T_4 (K and ^oF)

_______(5) Table of temperature and pressure at each major thermodynamic station at each % load condition.

______(10) Presentation of hand calculations for base case

_______(5) Attached copy of Matlab script

_______(5) Overall appearance and organization

Technical Memorandum

To:

From:

Date:

Subject:

Objective: What are you trying to determine and why?

Procedure: How did you address the problem? What are the major assumptions? Indicate the basic principles applied, algorithms used and the calculation procedure.

Results and Discussion: The outcome of your work. Refer to the tables and plots and discuss (i) what they show (ii) the trends observed.

Conclusions/Recommendations: What have you learned?

Appendices:

The algorithm map and computer input/output listings

Tables and Plots

Sample calculations

Numerical results

The printout of the code (include a digital copy on a CD)

Be concise and brief; get to the point.
Use this opportunity to practice your writing skills!