EML 3303C and EAS 3800C

Mechanical and Aerospace Engineering Measurements

Jet Engine Virtual laboratory

(Solo assignment – Extra Credit worth 1 Grade Percentage Point)

I) Objectives:

1. Practice virtual testing of jet engine performance (by measuring thrust, fuel consumption, and efficiency) under different operating conditions.
2. Gain familiarity with jet engine components and their respective function.
3. Background:

Jet engines typically follow the Brayton thermodynamic cycle ([link video](https://youtu.be/vTwG2I8Tl7o)). These engines are complex and consist of many components ([this link](https://www.youtube.com/watch?v=L24Wf0VlTE0) is an overview of how jet engines work). The main components are:

* Diffuser
* Compressor
* Combustion chamber
* Turbine
* Nozzle

1. Apparatus:

A screenshot of a computer

Description automatically generatedNational Instruments LabVIEW application that you can run on your computer (see **Figure 1**)

**Figure 1: LabVIEW application**

1. Procedure:

Your team is assigned an aircraft and an operating location (see **Table 1**). All members of your team will have the same aircraft and location while individual team members have their own flight speed according to their last name alphabetical order in their team. The speeds are in the following order: 350, 400, 450, 500, or 550 mph. For example, the first member of the team will run measurements at the first speed and so on. Since this is a solo assignment, the student is only responsible for the speed assigned to him/her.

**Table 1: Aircraft and Location Combinations**

|  |  |  |
| --- | --- | --- |
| **Team** | **Aircraft** | **Location** |
| **1** | Boeing 737 | Orlando, FL |
| **2** | Airbus A330 | Orlando, FL |
| **3** | Boeing 777 | Orlando, FL |
| **4** | Boeing 737 | Cruising Altitude |
| **5** | Airbus A330 | Cruising Altitude |
| **6** | Boeing 777 | Cruising Altitude |

**IV.A Preparing to run the LabVIEW application.**

This section describes how to prepare to run the application. See [this video](https://youtu.be/S7S-XxFXHU4) for a demonstration of the application’s features.

1. Download the three files from Webcourses. All three files must be stored in the same folder and file names must remain as listed here for the application to work.
   1. jet\_engine\_app\_mp4.exe is the LabVIEW application.
   2. jet\_engine\_video\_mp4.mp4 is the source for the video shown in the application.
   3. example.lvm is an example of the measured data saved by LabVIEW. This file contains the mean and standard deviation for the three dependent variables: thrust, fuel mass flow rate, and thermal efficiency. The operating conditions (compressor pressure ratio (CPR) and bypass ratio (BPR)) are also included.
2. Open the application. If upon opening the application appears distorted, adjust the vertical scroll bar to return the appearance to normal.
3. If the application automatically runs, click the red stop sign in the top left corner to stop it.
4. Click the folder icon at the top center of the screen under the red text, and then navigate to the directory where this application is located and select the “example.lvm” file then click “OK.”

**IV.B Setting values that will remain constant for all trials**

1. On the User Inputs panel (far left of the screen), select the appropriate “Location” for your team (see **Table 1**). This will set the appropriate ambient temperature and pressure for that location.
2. Click on the image of an engine under “Aircraft,” and select the appropriate aircraft for your team. This selection sets the fan diameter, compressor pressure ratio, and bypass ratio at the typical design conditions. This information is also provided in **Table 2** (this information is already included in the application). The image of each jet engine is paired with a human figure to provide a sense of scale.
3. Below the “Aircraft” selection, use the slider to set the “Nominal Flight Speed” as determined by alphabetical order of your last name in the team. Only use the speed assigned to you.
4. Below “Nominal Flight Speed,” set the “Sample Duration” to 30 s.

**Table 2: Aircraft Characteristics**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Aircraft | Engine | Fan Diameter (m) | Pressure Ratio | Bypass Ratio |
| Boeing 737 | CFM LEAP-1B | 1.73 | 22:1 | 9:1 |
| Airbus A330 | CF6-80E | 2.19 | 33.6:1 | 5:1 |
| Boeing 777 | PW4000 | 2.85 | 34.2:1 | 6.4:1 |

**IV.C.1 Fix BPR and vary CPR**

1. Fix the bypass ratio (BPR) at the design condition by setting the “Adjust BPR” slider to 0.
2. Now, you are going to change CPR around its design value and save the measured thrust, fuel mass flow rate, and thermal efficiency.
3. Use the “Adjust CPR” slider to choose 10 CPR values in the available range of the slider.
4. Run the simulation (at each slider setting) by clicking the white arrow in the top left corner. The data will automatically be saved as an “.lvm” file in the location you selected from the folder icon (should be same as application location).
5. Open the saved file in Excel to ensure data was properly saved and familiarize yourself with the data included. The three measured variables (mean and standard deviation) will be in the bottom row of the file.
6. Stop the trial by clicking the red stop sign in LabVIEW.
7. Choose a new setting for “Adjust CPR” while leaving all other settings unchanged.
8. Repeat steps 4-6 until you have 10 saved files, each with a different CPR.

**IV.C.2 Fix CPR and vary BPR**

1. Fix the compressor pressure ratio (CPR) at the design condition by setting the “Adjust CPR” slider to 0.
2. Now, you are going to change BPR around its design value and save the measured thrust, fuel mass flow rate, and thermal efficiency.
3. Use the “Adjust BPR” slider to choose 10 BPR values in the available range of the slider.
4. Run the simulation (at each slider setting) by clicking the white arrow in the top left corner. The data will automatically be saved as an “.lvm” file in the location you selected from the folder icon (should be same as application location).
5. Open the saved file in Excel to ensure data was properly saved and familiarize yourself with the data included. The three measured variables (mean and standard deviation) will be in the bottom row of the file.
6. Stop the trial by clicking the red stop sign in LabVIEW.
7. Choose a new setting for “Adjust BPR” while leaving all other settings unchanged.
8. Repeat steps 4-6 until you have 10 saved files, each with a different BPR.

**IV.D Plotting the results**

You will create six separate plots total: three showing the influence of CPR on jet engine performance, and 3 showing the influence of BPR on jet engine performance. Be sure to include plot titles, axis labels, and variable units. The figures should be such that:

* [1 point] Figure 1: the mean thrust (y-axis) as a function of CPR (x-axis)
* [1 point] Figure 2: the mean fuel mass flow rate as a function of CPR
* [1 point] Figure 3: the mean thermal efficiency as a function of CPR
* [1 point] Figure 4: the mean thrust as a function of BPR
* [1 point] Figure 5: the mean fuel mass flow rate as a function of BPR
* [1 point] Figure 6: the mean thermal efficiency as a function of BPR

Hint 1: Each figure will contain 10 operating conditions. Since each condition is saved in a separate file, it is advisable that you combine the 10 different CPR conditions in one spreadsheet and the 10 different BPR conditions in another spreadsheet before generating these figures.

Hint 2: You are not required to plot the standard deviation of the measured quantities.

**IV.E Submitting the assignment**

Combine all six figures in one PDF document and upload to Webcourses.

**Note:** Your computer may not have the “LabVIEW Run-Time Engine” installed. This a free download from NI that is also posted on Webcourses. Installation of this Engine is needed in order to run the LabVIEW application for this experiment.