Instructions for Engine Modeling Mini-Project

In this project, you will simulate a 4-stroke spark-ignition, naturally aspirated engine using a MATLAB two-zone heat release model. You will choose an engine about which the bore, stroke, connecting rod length, and other manufacturer’s information can be found. Based on the engine chosen, you will modify the volumetric efficiency and engine friction as a function of engine speed. You will also assign air-fuel ratios to different engine operating points and determine MBT timing. You will be expected to relate your findings to typical engine design/operating parameters we have explored in this course.

A set of MATLAB files is provided to assist you in this effort. Make sure to save all MATLAB files in the same directory or folder, and do not change the name of the files (these are referenced throughout the main code). Before getting started, review lecture material in lecture 25.

1. Put your engine’s bore, stroke, connecting rod length, number of cylinders, compression ratio, and valve timing into the model. Exhaust valve timing can be found on performance camshaft websites (remember, this model runs from 0 to 360 degrees, with 180 degrees being TDC).
2. If your engine has EGR, comment-out line 369 of the two-zone script, and uncomment line 368. This corrects the inlet temperature based on EGR. Note: In order to see the effects of EGR on NO, the timing and burn duration have to be adjusted (see pages 836-841 in the textbook).
3. Based on the chosen engine, construct a customized volumetric efficiency profile and update this within the volumetric efficiency function (provided on the Mindworks website). This should be as simple as creating a few volumetric efficiency data points (relative to engine speed) and curve-fitting these points (in Excel or Matlab).
4. Based on the chosen engine, modify the linear friction equation. The friction equation provided in the two-zone script (line 53) is adjusted for motorcycle operation. Reference your textbook or Blair’s textbook (cited in Jeremy’s thesis) for help adjusting this. Site any external sources that you use.
5. Based on the chosen engine, construct a custom air-fuel ratio map over your engine’s operating range. You might be able to find an aftermarket map, or you might have to make assumptions based on the type of engine. This is for the purpose of step 6; don’t get too obsessive about this. Site any external sources that you use.
6. Run your MATLAB code using pre-assigned speeds, loads, air-fuel ratios (by changing lambda, line 78), and burn-durations. The burn-duration will need to be adjusted relative to engine speeds and air-fuel ratios (pages 390-395 and 827-829 from the textbook describe changes in burn duration and spark-timing, respectively). Adjusting burn duration is extremely important to getting accurate results, so spend a little time on it.
7. Find the MBT spark-timing for each speed and load point. Record your observed imep and MBT setting. You should have at least 15 points. Suggested point distribution includes 5 different RPM settings and 3 throttle positions at each RPM. This will ensure accurate BSFC and emissions maps.
8. At each operating point, store RPM, Torque, BSFC, NO emissions, and HC emissions in an Excel file. Each output (i.e. RPM, Torque, etc.) should be stored in an individual column of the Excel file. Make sure that RPM, Torque, and BSFC values are stored in the first 3 columns of the Excel file. Save the variable as “data”. The file “JeremyData” is provided as an example (make sure to save the Excel file in the same directory as the BSFC file).
9. In the “BSFCcode.m” file, update line 8 to “jdata=xlsread('data');”
10. By running the “BSFCcode.m” file, a BSFC map will be produced. Construct NO and HC emissions maps by adding additional lines and plots to the “BSFCcode.m” file (i.e. NO and HC emissions should already be stored in the Excel file, simply plot these in the same way as RPM, Torque, and BSFC values were plotted to create BSFC maps).

Your deliverables include:

* Specifications for engine model, geometry, IVC, EVO, and performance data
* Lambda tuning at different load/speed points, including rationale for selection
* Volumetric efficiency tuning at different speeds, including rationale for selection
* Spark Timing/Burn Angle across the operating envelop, including rationale for selection
* Plot and discussion of actual as well as theoretical power and torque as a function of speed
* Plot and discussion of BSFC map for your engine
* Plot and discussion of BS emissions maps for your engine (CO, HC, and NOx).
* ½ page reflection on your two most valuable lessons learned/insights about engine heat release modeling through this assignment, along with aspects of the simulation that you would like to learn more about/refine.
* Assess your performance on this exam using the problem solving rubric. Write a paragraph on the two greatest strengths exhibited in your engineering problem solving/documentation, why these are valuable, and why they should be sustained. Write a second paragraph on your two greatest areas for improvement in your engineering problem solving/documentation along with an action plan how to make each improvement.

