ME 2543

Simulation Methods in MATLAB

Spring 2023

Group Project 2 – Report

Please complete the following information and submit to Moodle by 12:00 noon on Thursday, 3/10.

Group number: **6**

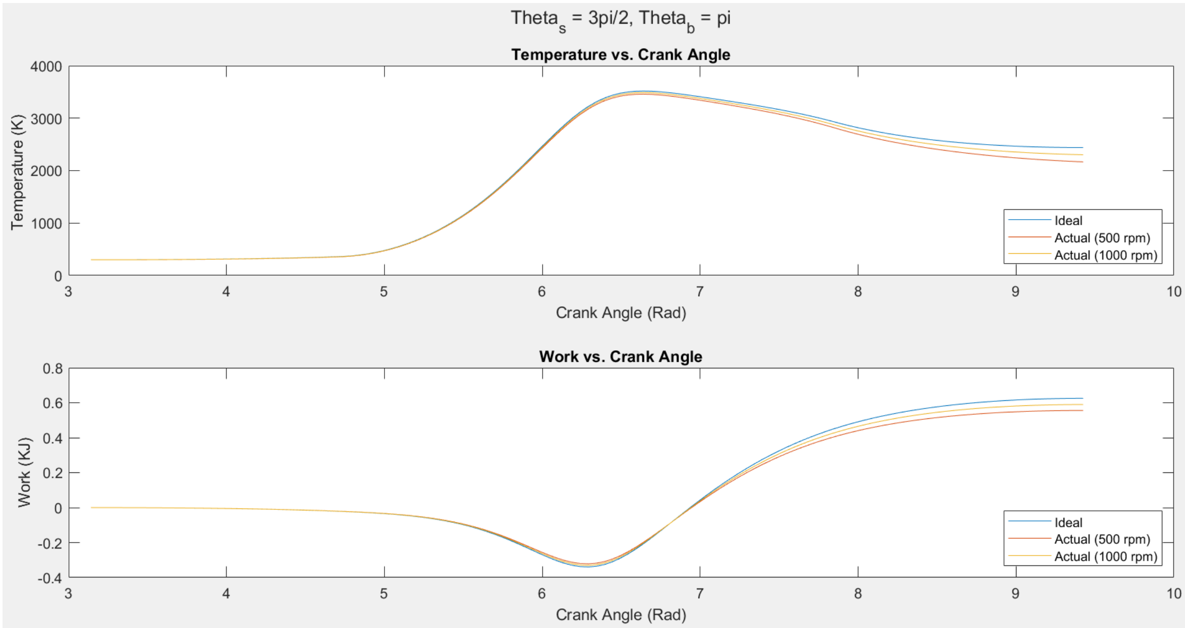
Group member's name	Tasks assigned (May include Tasks 1 – 7; Testing; Writing report, *etc.*)	Deadline (1 per task)
Chloe Blanchard	> Write MATLAB functions for x (heat fraction) and $dx/d\Theta$. > Update Report > Confirm that by-hand calculations for Mass and Volume match with the script. > Write Temp storing code. > Create tiled plot layout for T, P, W, V plots	> Thurs 4/20 >Wed 4/19 > Tues 4/25 >Wed 4/26 >Thurs 4/27
Carson Cooper	> Write ode45 code for solving Pressure and work out > Verify correctness of mass, volume, $dx/d\Theta$, $dv/d\Theta$ functions by hand > Write temperature storing code. > Add mass blowby and heat loss terms to ode45 code, make part 2 plots (actual vs ideal models) > Finalize report	>Tues 4/25 >Tues 4/25 >Wed 4/26 >Thurs 4/27 >Wed 5/3
Taylor Gautreaux	No contribution	

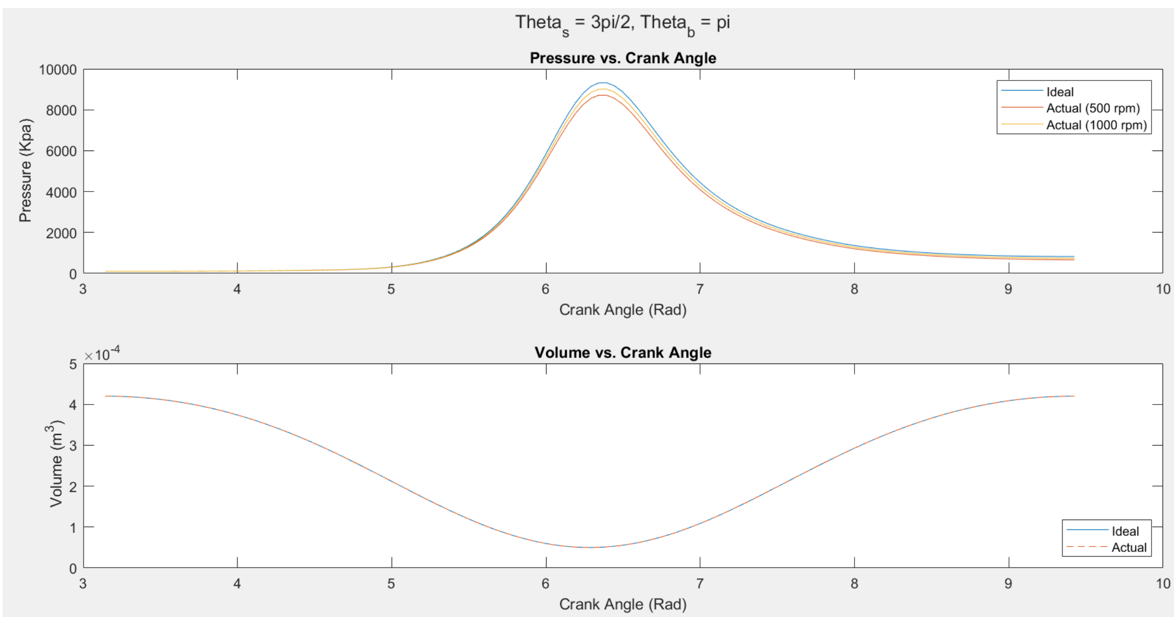
Group member's name	Tasks assigned **(May include Tasks 1 – 7; Testing; Writing report, *etc.*)**	Deadline **(1 per task)**
Philip Melton	> Write MATLAB functions for volume, dv/dΘ > Verify correctness of volume and dv/dΘ functions > Review part 1 code, develop approach to problem 2 > Finalize report	> Thurs 4/20 > Thurs 4/20 > Tues 4/25 > May 5/3
Trey Nickens	No contribution	
Additional deadlines set by the group:	> General ode45 practice (all members) > Solve all initial conditions, (initial mass, state 1 volume...) > Solve part 1 (neglecting blow-by and heat transfer), make plots > Solve part 2, make plots > Finish report	> Tues 4/18 > Thurs 4/20 > Tues 4/23 > Tues 5/2 > Wed 5/3

This project involves the simulation of a reciprocating spark ignition engine. This device involves the alternating compression and expansion of air contained within a tightly sealed piston-cylinder. Fuel is periodically combusted inside the cylinder, causing a powerful explosion that forces the gas to heat up and expand which causes the piston to move. This linear, reciprocating motion is harnessed by a crank linkage that converts the piston work into the rotation of a shaft. This process can be modeled by a thermodynamic cycle, assuming ideal properties of air at room temperature. Corrections to account for air leaking out of the cylinder (mass blow-by) and heat transfer to the surroundings (heat loss) are made.

Part 1 considered an ideal case, where the terms for mass blow-by and heat loss were neglected. Several equations were given that related the pressure, volume, temperature, instantaneous fraction of heat added (x), and work out, to the crank angle (theta). Initially, a plan was constructed to set up 4 equations using the given initial conditions. The first equations considered were the (eq.5) Volume and (eq. 6) heat-fraction equations. Setting up the ODE-45 command required functions for volume and the heat fraction, as well as functions to evaluate their derivatives. These equations were created as local functions within the script using the given parameters. By hand calculations it was confirmed the functions were set up properly. After this, the derivatives of both the volume and heat fraction expressions were taken using the diff(f) MATLAB command. The initial mass, M(θ), was calculated using the volume function evaluated with theta equal to pi and the ideal gas relation (PV = mRT). Once all the functions were running properly, the ODE-45 code was set up to solve pressure and work out. A maximum step size of 0.05 was set to ensure smooth plots.

Once all functions and the ODE-45 code ran, it was found there was a pressure max of approximately 10 MPa, with a work-net output value of 0.62 kJ. The next step was to store temperature values as a function of crank angle. For this, a “for” loop was created that evaluated the temperature at many points within the theta domain (pi < t < 3pi) using the ideal gas relation and the pressure values obtained from the ode-45. With values for volume, pressure, temperature, and work out, the four plots were created. For a quick check, the graphs were compared to those of the Otto cycle, and ideal model for the spark ignition engine. Our plots showed a similar trend to those of the Otto cycle. For Part two, the mass blow-by and heat loss terms were implemented. The Work and Pressure Values slightly decreased, which makes sense with energy leaking out of the system.





From the plots, at the point of minimum volume, or the" Top Dead Center" position with theta = 2pi = ~6.28 rad, the pressure and temperature both reach maximums. This makes sense, as the gas is expected to reach its most extreme conditions when at its maximum compression. The net- work starts out as negative, indicating work must be applied to get the system started. This would be done through applying some force to compress the gas initially. Accounting for mass blow-by and heat loss leads to a drop in pressures, temperatures, and the amount of useful work. It is also observed that the faster the engine is running (increasing omega), the closer the model gets to being ideal.