Spark-Timing Optimization Activity

Learning Objectives

1. Understand how the burn duration changes relative to the air-fuel ratio and engine speed.
2. Describe how the burn duration is influenced by laminar flame speed.
3. Identify how timing is influenced by engine speed and load.

Governing Equations

1. Weibe Function (constants 3 and 5 are used)

```
X(i) = 1-exp(-5*((theta(i)-theta_0)/theta_b)^3);
```

2. Annand's Heat Transfer Prediction Method

```
%Calculates Convective Losses Into Wall As A Function Of Crank Angle
DQ_w(i) = (h_g(i)+C_R(i))*A*(T(i-1)-T_w)*(60/(360*RPM));
%Calculates Change In Heat Transfer (total) As A Function Of Crank
%Angle
DQ(i) = eta_comb*LHV*M_F(i)*DX(i)-DQ_w(i);
```

3. Apparent Heat Release Model

```
DT(i)=T(i-1)*(gamma(i-1)-1)*((1/(P(i-1)*V(i-1)))*DQ(i)...
    -(1/V(i-1))*DV(i));
DP(i)=(-P(i-1)/V(i-1))*DV(i)+(P(i-1)/T(i-1))*DT(i);
P(i) = P(i-1)+DP(i);
```

- Choose to optimize spark-timing relative to torque or power.
- Place the main MATLAB model within a function (be sure to save the function as the correct name i.e. "timingfunc")

```
function [W_dot_ac,T_ac]=timingfunc(theta_0)
%PLACE MATLAB MODEL HERE
end
```

The "function" statement says to input "theta_0" values and output "W_dot_ac" and "T_ac" values. Theta_0 is the spark advance, and W_dot_ac and T_ac are power and torque values, respectively.

- Create a script that calls the function.

```
clear all;
close all;
clc;

%Set Spark Angle Bounds
theta_st = 144;
theta_fin=160;
%Preallocate w
W_dot_ac(1:theta_st-theta_fin)=zeros;
T_ac(1:theta_st-theta_fin)=zeros;
%Changes Spark Angle As A Function Of I
theta_0=theta_st;
theta_o(1)=theta_0;
for i=1:(theta_fin-(theta_st))
    [W_dot_ac(i),T_ac(i)]=timingfunc(theta_0);
    theta_0=theta_0+1;
    theta_o(i)=theta_0;
end
```

Theta_st and theta_fin specify the range over which timing is optimized. A "for" loop is used to specify each angle over the specified range. Notice that the function is called on the first line inside of the "for" loop.

- Specify plotting statements in the call script

```
figure(1)
plot(theta_o,W_dot_ac,'k.')
grid on;
title('Spark Advance Vs. Power Output')
xlabel('Spark Advance [deg]')
ylabel('Power [kW]')

figure(2)
plot(theta_o,T_ac,'k.')
grid on;
title('Spark Advance Vs. Torque 6000 RPM')
xlabel('Spark Advance [deg]')
ylabel('Torque [N*m]')
```

These plotting statements create plots relative to torque and power outputs.

- Specify engine inputs in the main model (shown below).
- Comment-out the spark-advance, “clear all”, “close all”, and “clc” within the main model.
- Assume a burn duration based on the critical thinking questions.

```
%Engine Inputs
Load = .9;            %Engine Load (Affects Inlet Pressure)
RPM = 6000;           %Revolutions Per Minute [1/min]
L = (53.6/1000);      %Stroke of Engine [m]
B = (77/1000);      %Bore of Engine [m]
l = .0935;            %Length of Engine Connecting Rod [m]
N_cyl = 1;            %Number of Cylinders [unitless]
C_r = 12.5;           %Compression Ratio [unitless]
N_r = 2;              %Number of Revolutions Per Power Stroke
theta_b = 70;         %Combustion Burn Duration [degrees]
%theta_0 = 145;        %Crank Angle At Start of Combustion [degrees]
theta_f = theta_0+theta_b; %Final Comb. Angle [degrees]
IVC = 0;              %Time [degrees] when Intake Valve Closes
EVO = 314;            %Time [degrees] when Exhaust Valve Opens
```