Torque/Horsepower

The Briggs and Stratton engine doesn't perform in the same matter every time it's run. The inherent nature of a carbureted single cylinder engine results in small variations in performance between runs. To make sure our dyne controller could read the correct torque/HP from the start, known weight was hung off the three foot dyno lever arm and the proper value was seen on the controller and in the LabVIEW software.

We then ran the engine to full throttle multiple times. After adjusting settings in lab view, we were able to obtain the following torque/HP vs. Engine rpm curve shown below. Horsepower was found in LabVIEW based off the torque values. The second graph comparing two runs shows that our system has repeatability. The difference in the low RPM values is due to the throttle being decreased before minimum RPM was reached. This is done to reduce the chugging that occurs at low RPM.

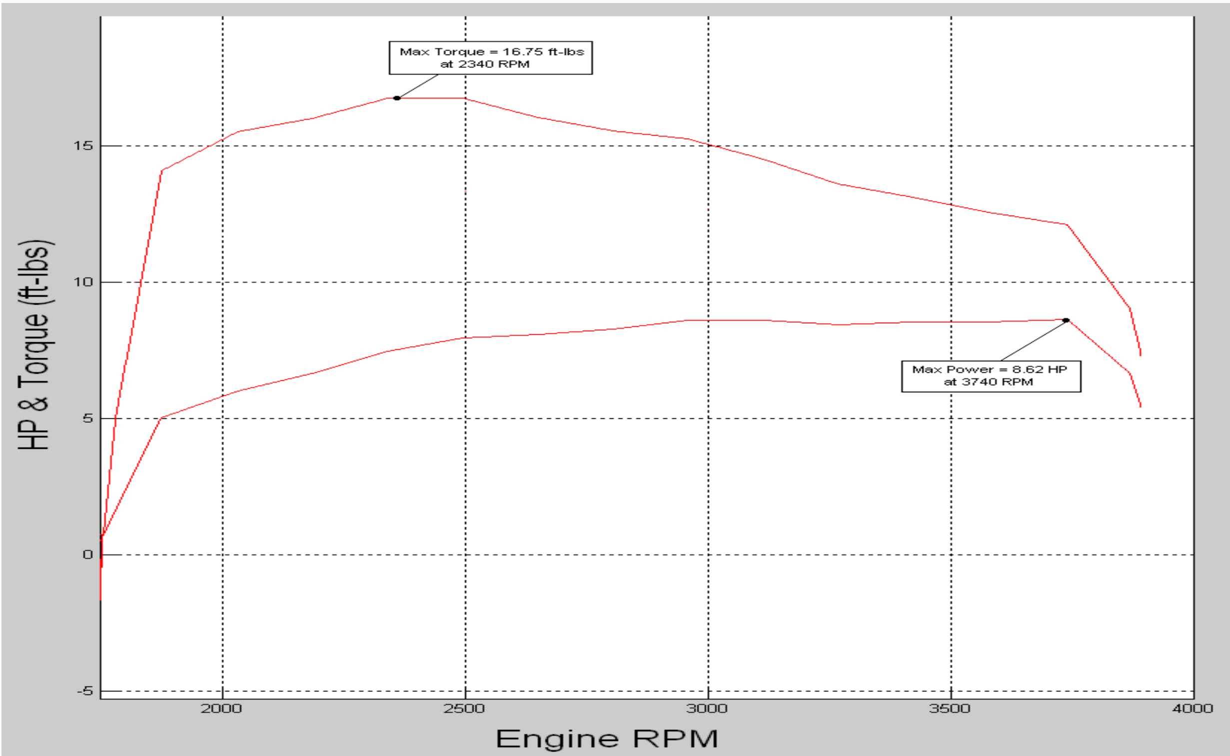
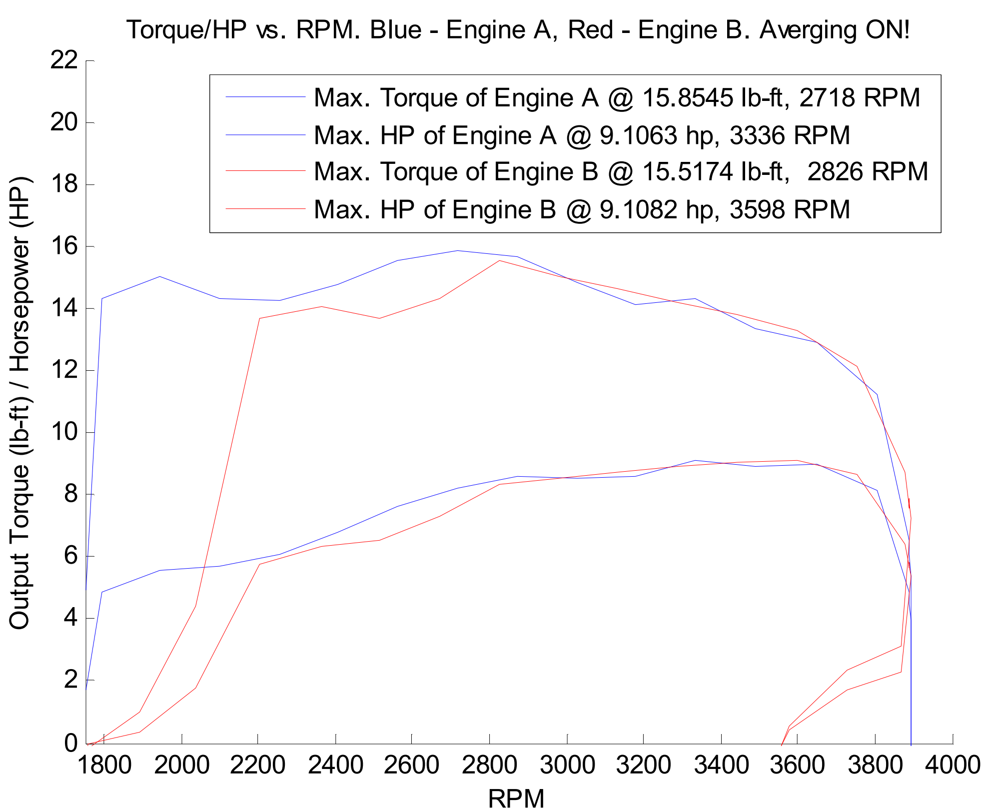


Figure 1: RIT Briggs and Stratton engine torque/hp vs. Engine rpm graph.



To make sure our results were correct, we referenced known torque/hp data from the Michigan Baja team. The Briggs and Stratton engine is rated to 10 hp and could see as high as 18 ft-lbs of torque according to some forums.

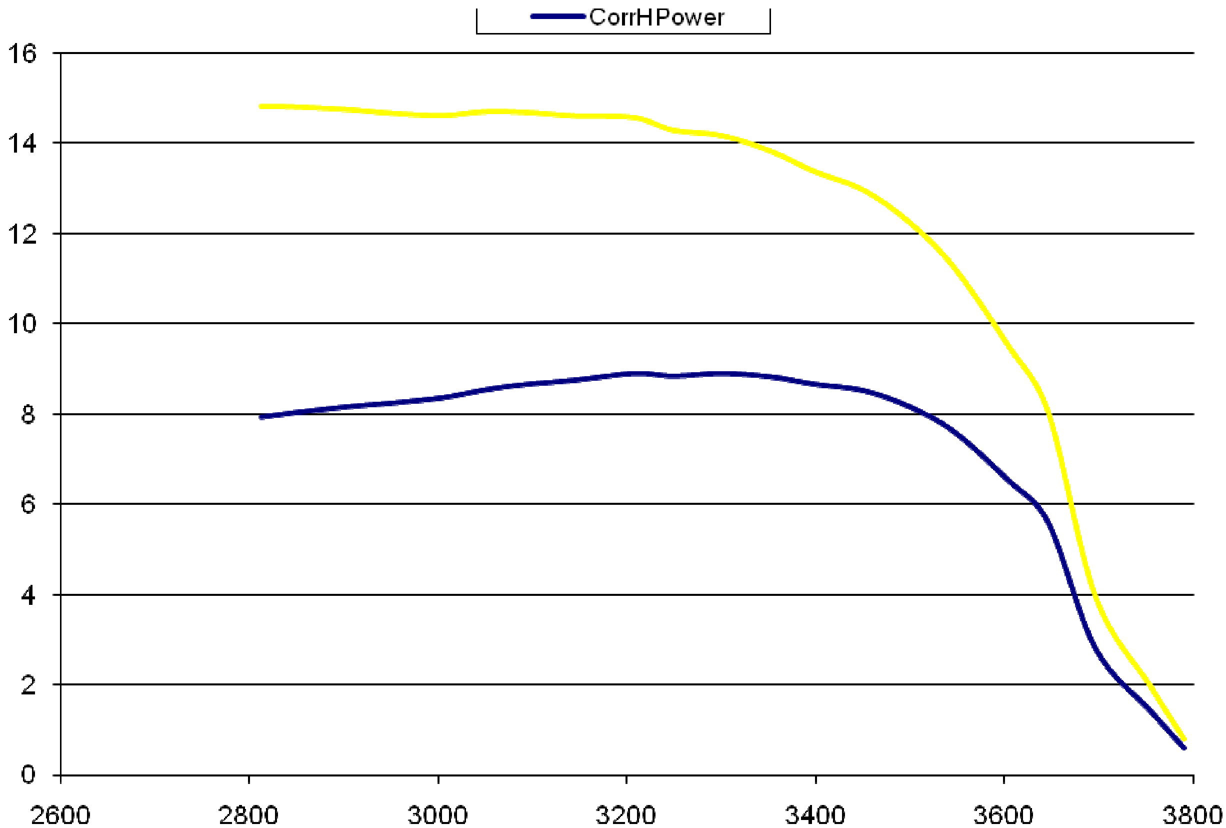


Figure 2: Michigan Baja team torque/hp vs. Engine rpm graph

The Michigan results matched up relatively well with the results obtained during testing.

Mass air flow sensor

http://www.csgnetwork.com/cfmcalc.html

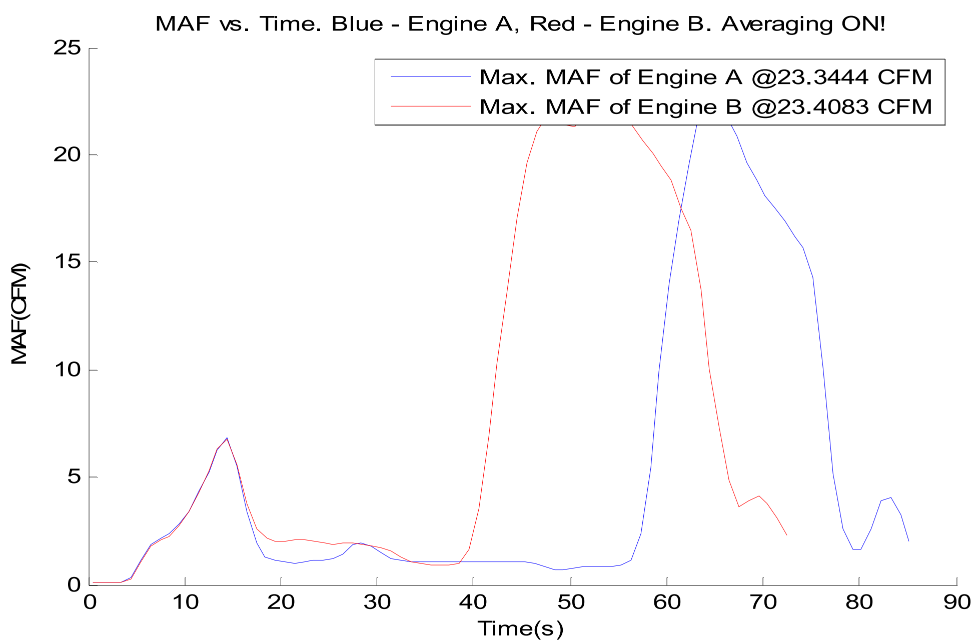
The theoretical mass air flow of our engine is given by the equation:

Equation 1: TMAF=CID*RPM*VE / 3456

TMAF=18.612in^3*3900*1.00/3456 = 21 CFM

Since the volumetric efficiency would not be one, we would expect a lower value than this max. We have not, however, taken into account the obstruction the actual sensor creates in the air steam going into the engine. This will reduce the total area and thus increase the actual speed of the flow. Thus when you convert air speed into volumetric flow rate the flow rate may read higher, as is shown in Fig. 3.

Below is a graph showing airflow (CFM) vs. engine RPM.

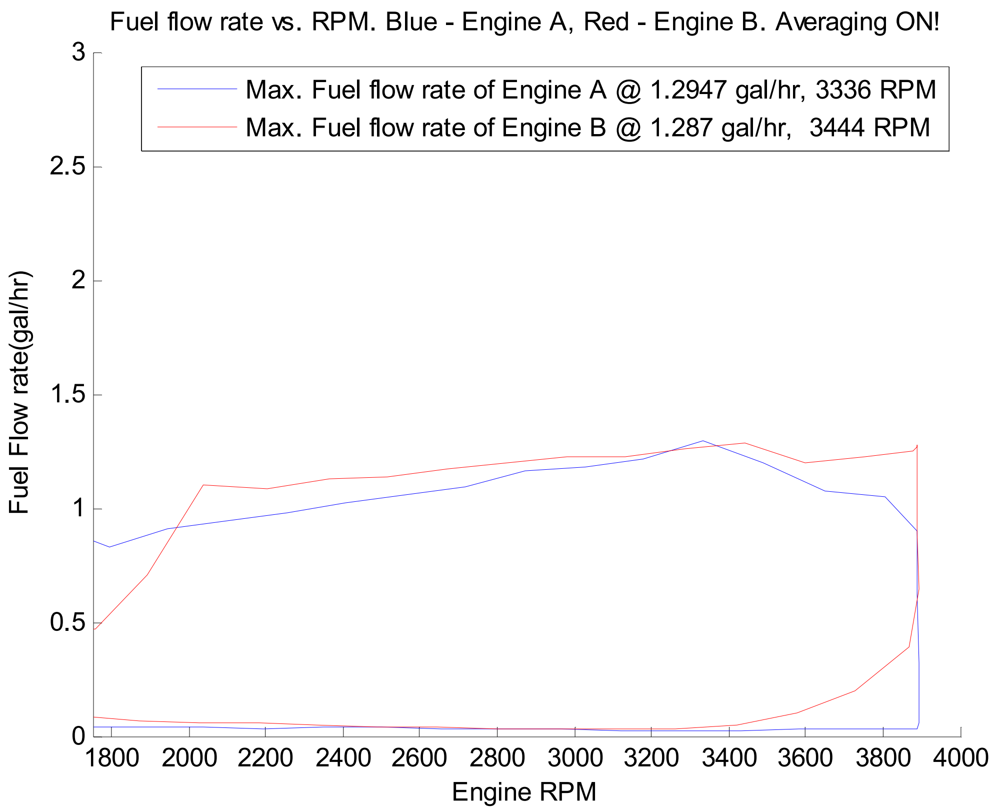


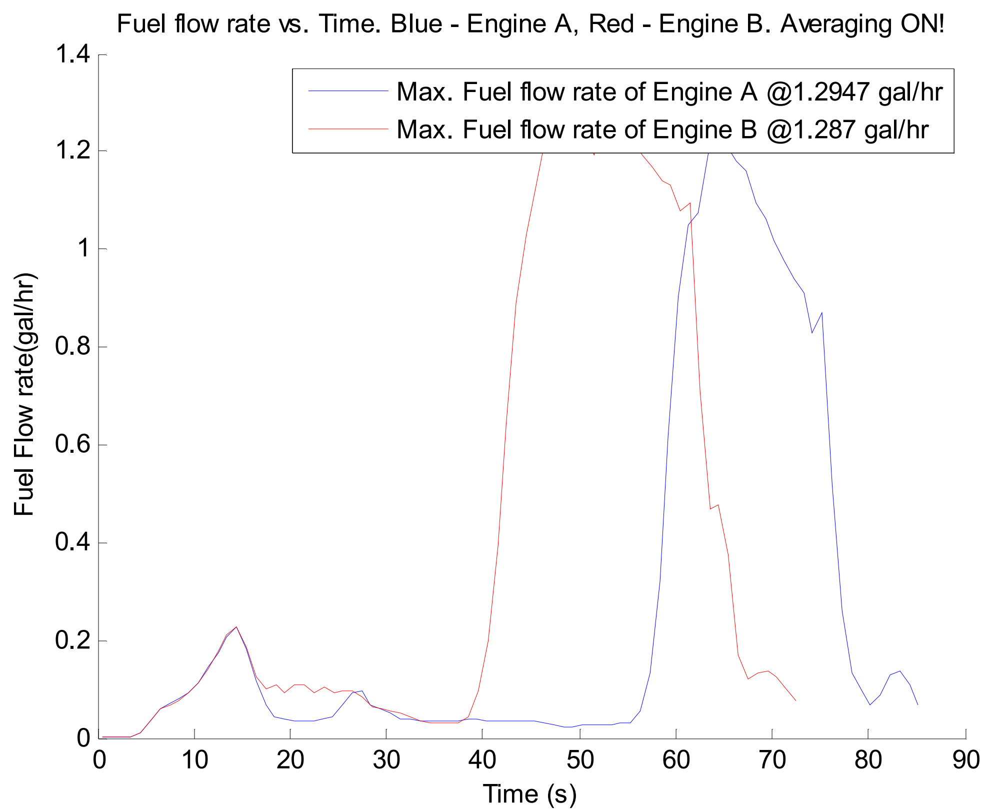
Fuel flow rate

To calculate the fuel flow rate in the engine we used the following equation based off of the air flow rate value and A/F ratio:

Equation 2: Fuel flow=(1/AFR)*MAF.

The following graph shows the fuel flow vs. RPM.





To make sure we were getting correct values for fuel flow rate, we based the accuracy on the fact that the RIT Baja team uses about .5 gal/hour of fuel during a race, but does not run at full throttle for the entire time. This value still seems slightly high; however, it does provide a standard of comparison from one engine to the next, which was the request of the customer.

0-2 sensor

The 0-2 sensor measured the A/F ratio of our engine dyno runs. Intuition tells us that the Briggs and Stratton engine should be running rich at idle and throughout its entire rpm range. The A/F ratio should start at the outer range value of the sensor when the engine is off, decrease to a lean condition from 15 to 18 at idle because of the dyno forcing it to be that way, and drop slowly down towards 14.7 when engine rpm and throttle increase. The following graph shows the A/F ratio based on engine RPM.

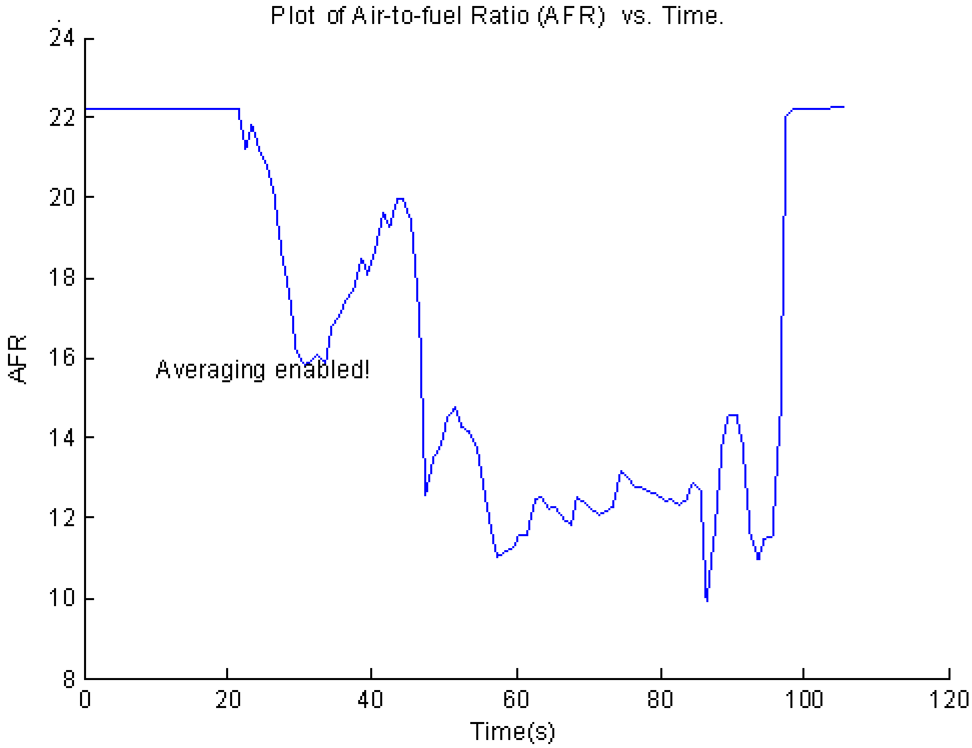
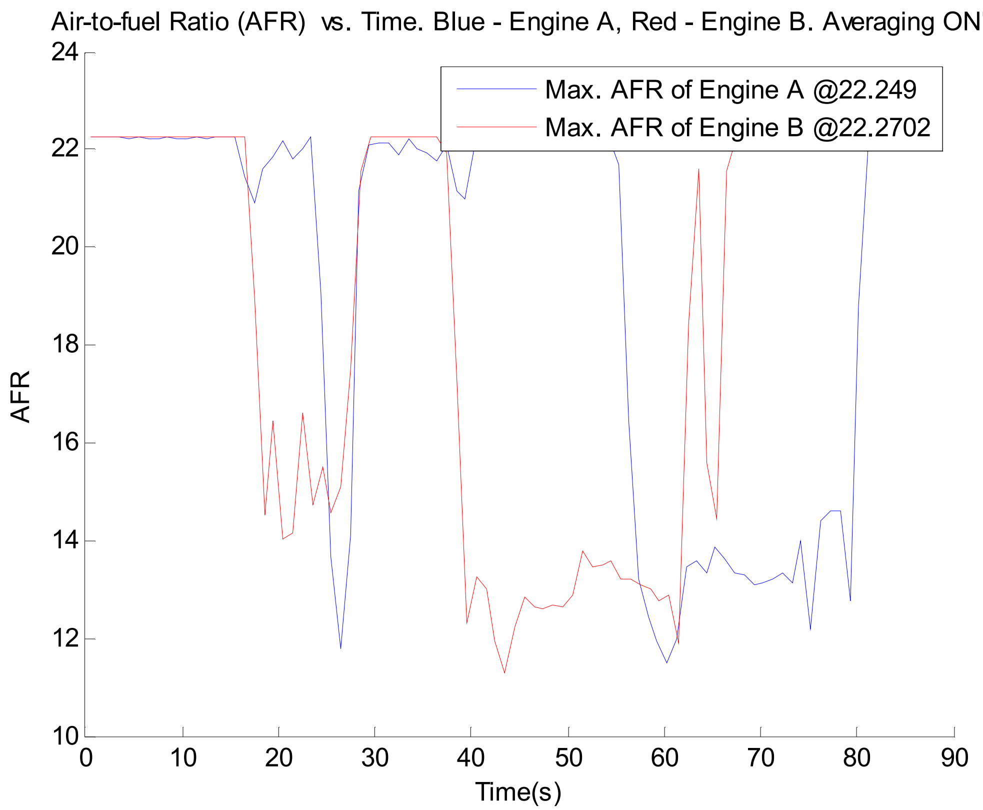


Figure 5



Thermocouple sensors

The thermocouples range was tested by lighting a match and seeing what temperature the thermocouple could read. The temperatures of the block, muffler, oil, air intake, and dyno room were taken and ran through LabVIEW. The temperature of each thermocouple with the engine off should read close to the dyno room temperature of around 68 degrees. We verified the temperatures of the block, muffler, and room with a laser thermometer ourselves. The temperature of the oil, muffler, and block all increase as engine rpm increases.

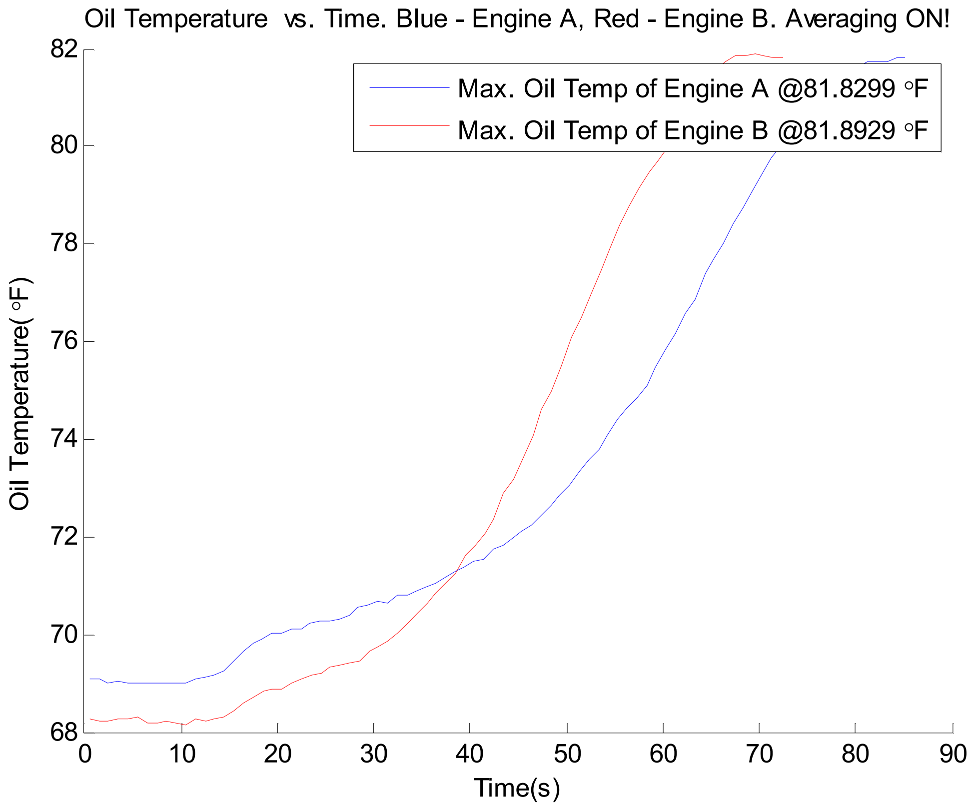

Oil Temperature vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. Oil Temp of Engine A @81.8299 °F
Max. Oil Temp of Engine B @81.8929 °F
Oil Temperature(°F)
Time(s)
82
80
78
76
74
72
70
68
0
10
20
30
40
50
60
70
80
90

Figure 6

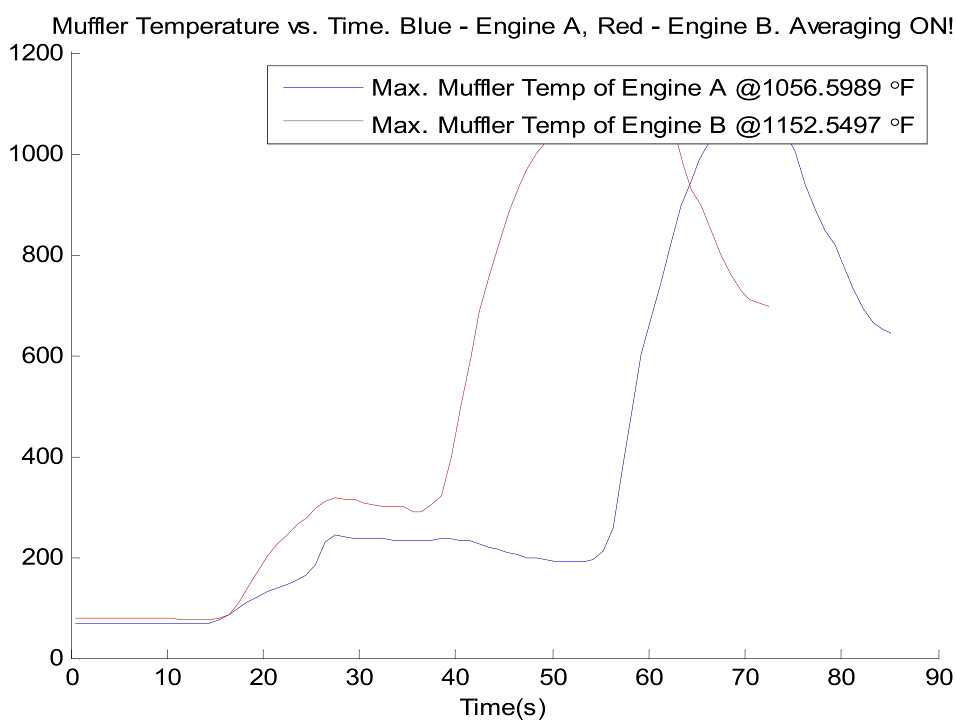
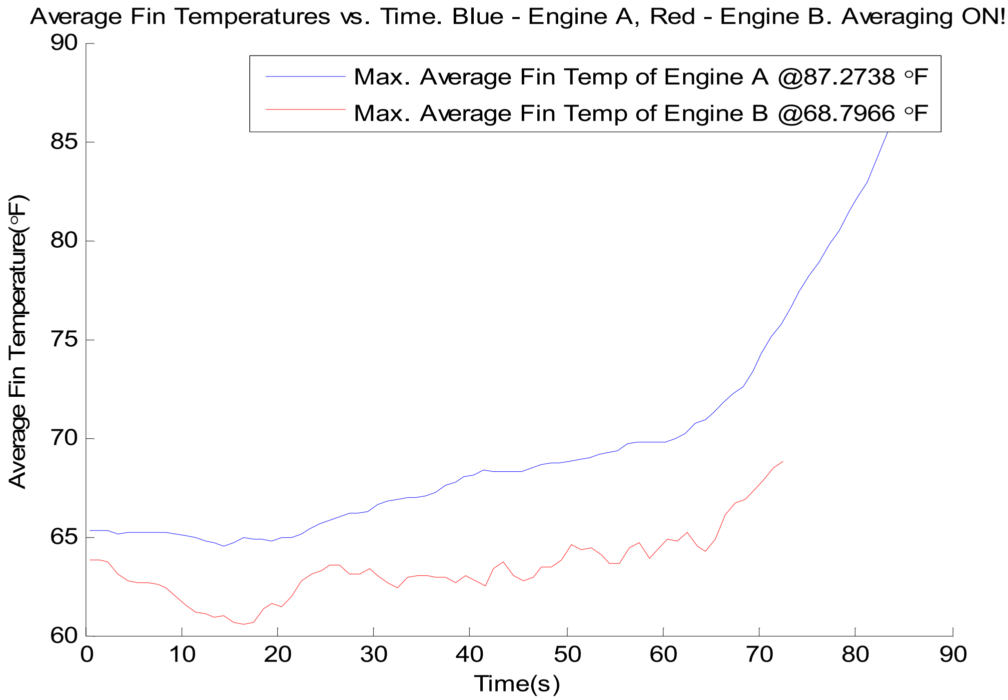
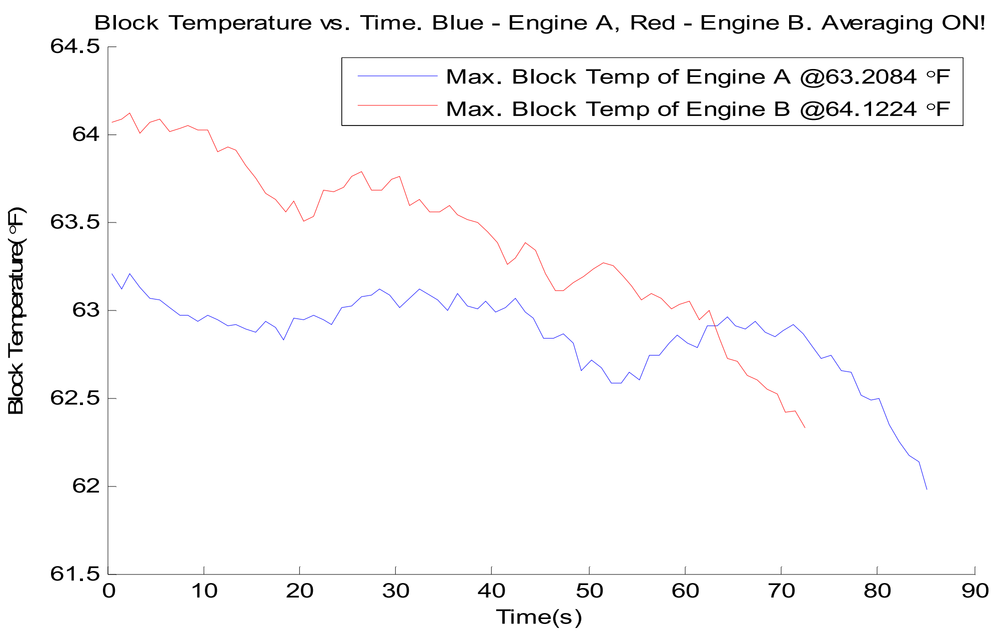
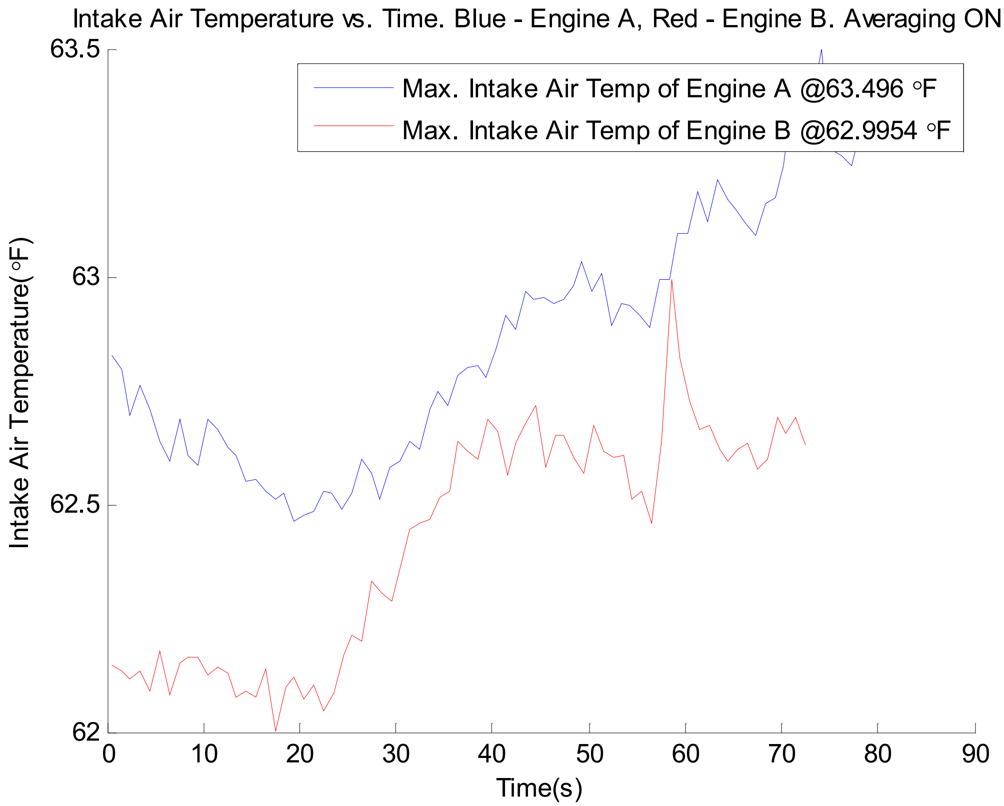

Muffler Temperature vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. Muffler Temp of Engine A @1056.5989 °F
Max. Muffler Temp of Engine B @1152.5497 °F
Time(s)
1200
1000
800
600
400
200
0
0
10
20
30
40
50
60
70
80
90

Figure 7


Average Fin Temperatures vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. Average Fin Temp of Engine A @87.2738 °F
Max. Average Fin Temp of Engine B @68.7966 °F
Average Fin Temperature(°F)
Time(s)
90
85
80
75
70
65
60
0
10
20
30
40
50
60
70
80
90


Block Temperature vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. Block Temp of Engine A @63.2084 °F
Max. Block Temp of Engine B @64.1224 °F
Block Temperature(°F)
Time(s)
64.5
64
63.5
63
62.5
62
61.5
0
10
20
30
40
50
60
70
80
90



Intake Air Temperature vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. Intake Air Temp of Engine A @63.496 °F
Max. Intake Air Temp of Engine B @62.9954 °F
Intake Air Temperature(°F)
Time(s)
63.5
63
62.5
62
0
10
20
30
40
50
60
70
80
90

Pressure sensor

To verify our engine pressure sensor was getting the right data, we compared the TFX sensor value in the head to a pressure value we expect to see of 8 times atmospheric pressure because that is our compression ratio. Below are the graphs that show the P-V diagram of our engine for 1 combustion cycle. The head drilled for the pressure sensor was used on a worn out engine. We didn't want to test the PCB spark plug transducer because we didn't want to ruin the sensor in a bad engine. We predict that a newer engine would have a higher idle cylinder pressure. Validation for the pressure value with the TFX software will come when the PCB sensor is tested.

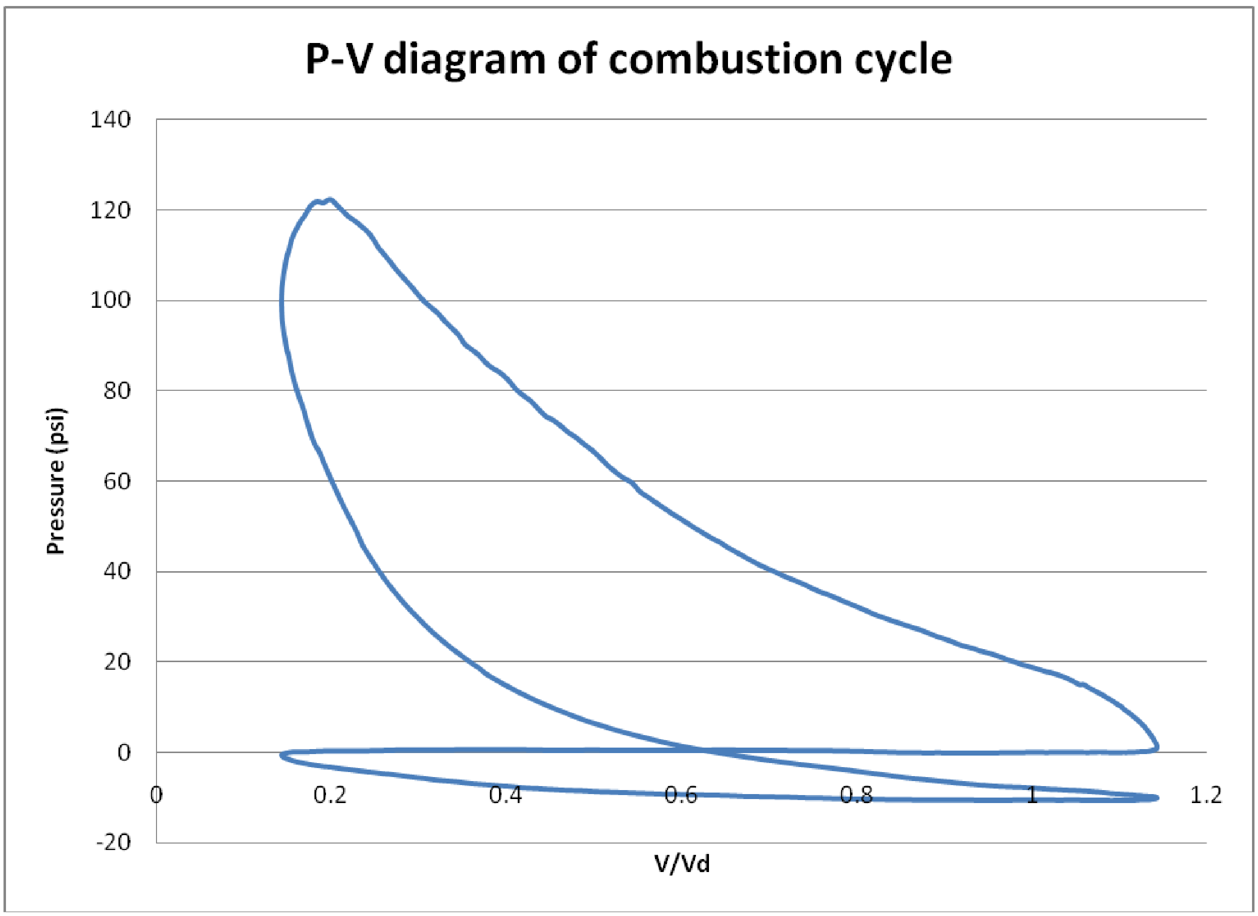


Figure 10: Kistler pressure sensor P-V diagram

Engine Encoder

The engine rpm is verified by comparing the engine rpm shown on a small tachometer with the rpm shown through the TFX software, and the Dyno RPM from the dyne controller when attached through the drive system. The difference between the TFX engine speed and the tachometer was roughly 10 to 20 rpm difference. The dyno rpm compared to the tachometer was also within about 10 rpm.

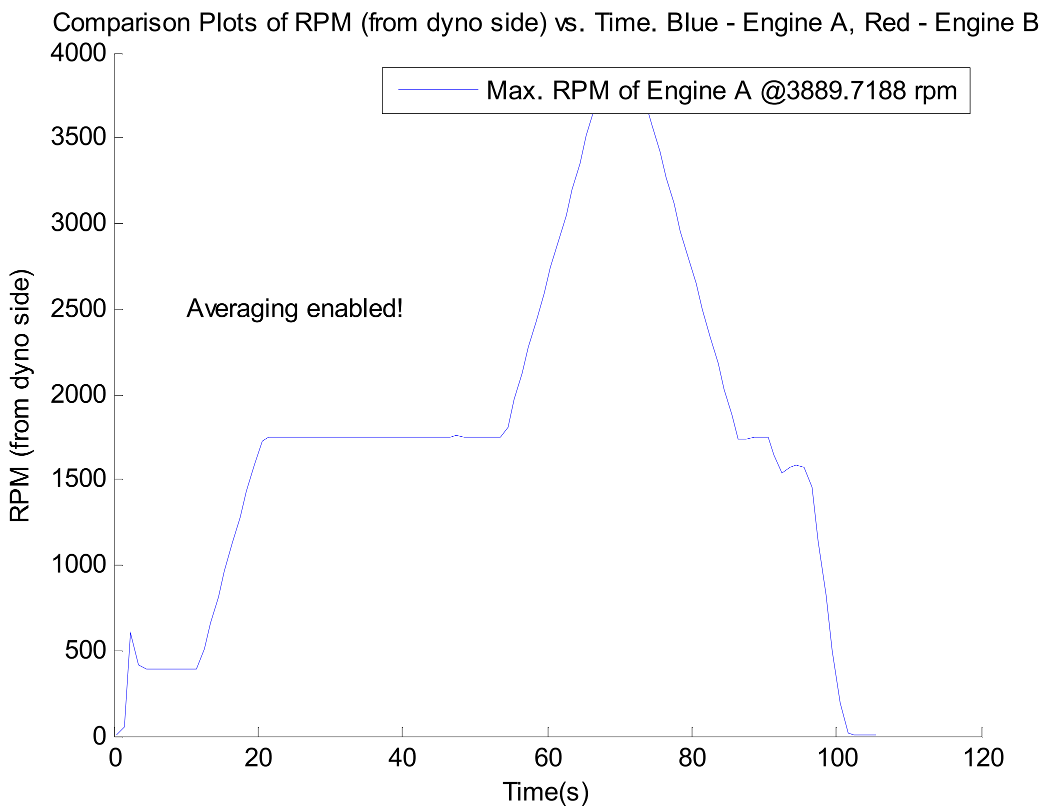
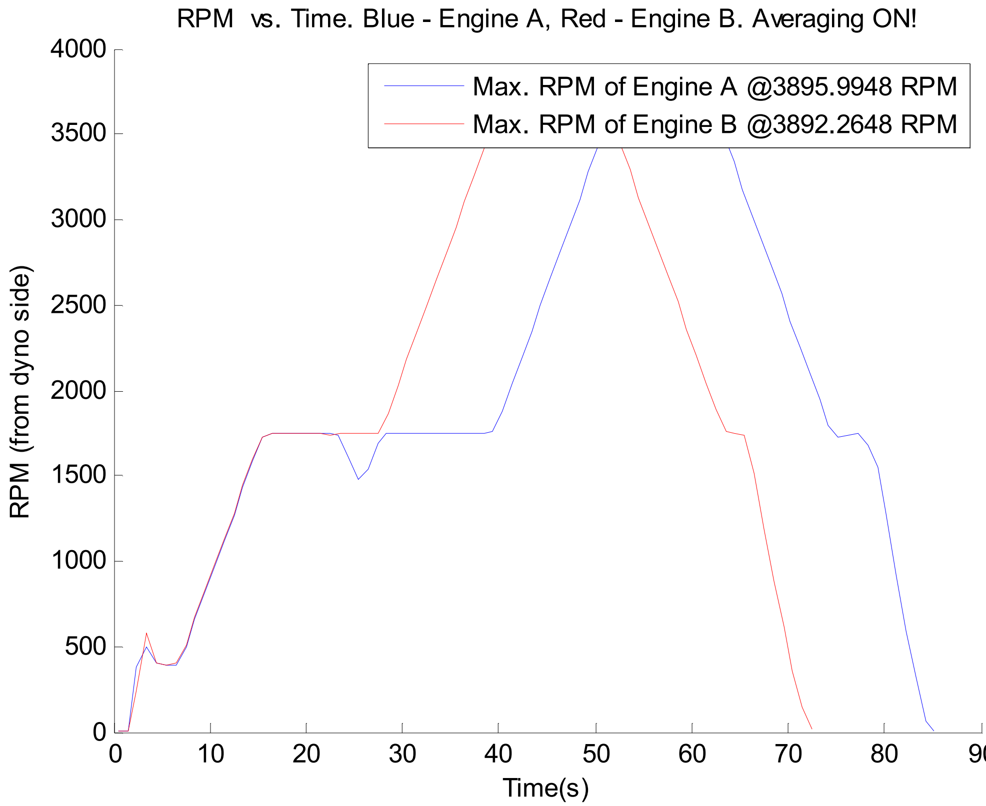


Figure 11: RPM based on the dyno



RPM vs. Time. Blue - Engine A, Red - Engine B. Averaging ON!
Max. RPM of Engine A @3895.9948 RPM
Max. RPM of Engine B @3892.2648 RPM
RPM (from dyno side)
Time(s)
0
500
1000
1500
2000
2500
3000
3500
4000
0
10
20
30
40
50
60
70
80
90