Fuel Consumption Monitoring System (FCMS)

Calibrated, Normalized, Real-time Measurement of Fuel Flow Rate on Heavy Diesel Vehicles Under Typical Service Conditions.

Problem: Meaningful evaluation of the performance of fuel efficient technologies is a difficult problem. Fuel logs are used by many operators to track fuel costs. However, fuel logs are influenced by many uncontrollable variables. They are generally not considered to be a definitive measurement of fuel consumption. The SAE standard J1321 is generally considered to be definitive. However, it uses timed test runs with weigh tanks. It also requires dedicated use of two vehicles, a test vehicle and control vehicle for the duration of the evaluation making it less practical. Actual service conditions are much more complicated than test runs, therefore, J1321 is not always predictive of savings that are obtained under typical service conditions.

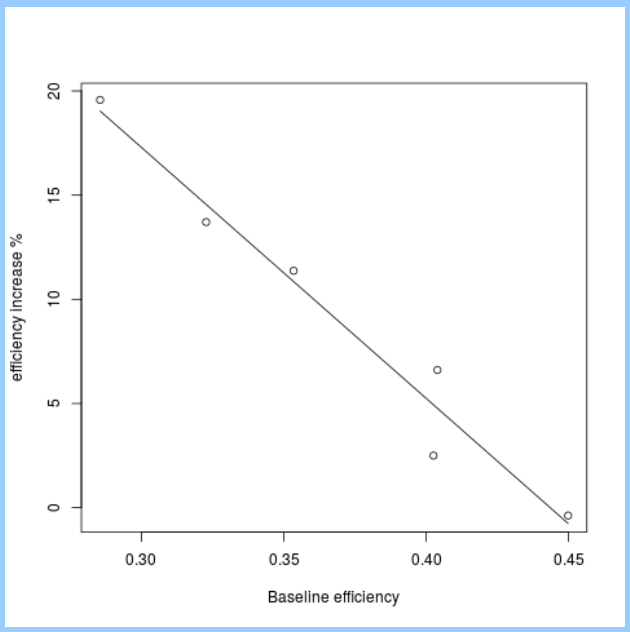
There are additional issues with HHO injection that make use of J1321 problematic. The efficiency increase resulting from HHO injection seems to correlate with baseline efficiency. (See box on Page 2) Efficiency increase can vary from zero up to 30% and is strongly influenced by HHO gas flow rate. A method is needed that will map the response of the engine to the HHO injection. SAE J1321 is designed to produce a single value of savings for a given set of test conditions. Therefore, it is completely unsuitable for any extensive data mapping procedure.

Solution: An electronics module that measures fuel consumption in real-time but, also measures indicated mean effective pressure (IMEP) and engine speed can be used to perform such a mapping procedure. The two variables of load (IMEP) and speed can serve as a frame of reference for normalizing the fuel consumption measurement. The J1321 standard describes a rationale for evaluating the performance of normalization. The same rationale could be applied to the FCMS normalization procedure. It may turn out that the FCMS normalization is better since it is easier to collect much larger amounts of data, on a single vehicle under typical service conditions.

Front view of FCMS electronics module. (103 mm long x 66 mm wide x 27 mm thick not including connector.)

Features of this system include:

- Fiber optic pressure sensor mounted in the cylinder head is used to measure pressure in at least one cylinder. This input is connected to a 16 bit analog-to-digital converter. Raw precision is measured at ± 0.014%. This can be reduced about eight-fold by means of appropriate filtering techniques.
- A variable reluctance sensor (VRS) generates a clock signal from a gear type trigger disk on the engine fly wheel or pulley. An integration of pressure as a function of volume is used to obtain the IMEP estimate.
- Pulse inputs from a volumetric flow meter (AquaMetro Contoil 8ECO) on the supply and return fuel lines provides fuel flow rates. RTD sensors upstream from the flow meter in both directions provides a temperature compensation for this measurement.
- Current transformers on the open and close leads of the fuel injector provide measurement of advance angle and injector pulse width on the cylinder that is being monitored.
- CAN interface allows monitoring of trouble codes and other general data supplied by the ECU.
- A 16 gigabyte miniature flash drive is located inside the module. Data is logged in ASCII form that can be pasted into spreadsheets and other documents on any computer for analysis.
- USB interface at 112 Kbits per second. Thus, a laptop can be temporarily connected to the module to perform configuration, verify operation and run diagnostics in the field.
- Ruggedized connector is resistant to vibration, moisture and dust. Therefore, the module can operate for extended periods in an engine compartment. Twist-lock action allows modules to be swapped out quickly. The module must be opened to replace the flash drive. This can be done at a bench or desk using nothing more than a small Phillips screw driver.
- Interface to a GPS receiver is provided. A pulse input allows the time base in the module to be synchronized with the UTC from the GPS receiver. Therefore, time and date stamps on the logged data are accurate to <1 second. GPS coordinates as well as elevation are logged to provide context for data analysis.
- RS485 interface provides connections to a local network of ancillary instrumentation modules. This provides additional flexibility for performing a variety of tests and evaluations.



Linear regression of percent increase vs. baseline efficiency for 32 amp HHO generator on Detroit Diesel Series 60 engine taken at Univ. of Northwest Ohio engine lab. p-value = 0.0006. Source: www.hho-research.org/wp15.pdf