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Varimax Engine Test to Determine The Effect of FPC® Upon Fuel Economy and Power Output by Western Australia Institute of Technology (WAIT)

Abstract

An extensive study by the Western Australian Institute of Technology (WAIT) collected considerable data demonstrating the effect of the FPC® catalyst on engine efficiency and power output while operating at varying engine speeds (rpm), engine loads, and injection timing. The test was designed to best illustrate the effectiveness of the FPC® combustion catalyst. In addition, the test conditions were aimed at determining the effect of the catalyst on the most commonly altered settings and conditions encountered during normal field operation of heavy-duty, compression-ignition engines.

Background

The objective of the WAIT study was to determine the effect of the FPC® burn rate modifying combustion catalyst on engine brake power and brake specific fuel consumption. In order to considerably broaden the scope of the test program in terms of relevance to simulating true commercial and industrial operating conditions, the following parameters were introduced to be varied accordingly:

(1) Engine speed

(2) Throttle setting

(3) Fuel Injection Timing

(4) The concentration of the catalyst in the diesel fuel

The manner in which each parameter was altered is described below:

* Engine speed in all tests was varied from 1600 rpm to 2400 rpm by increments of 200 rpm.

* Throttle settings were altered alternatively from half throttle to full throttle in the majority of the tests.

* Fuel injection timing was varied from 18 degrees before top dead center (BTDC) to 42 degrees BTDC, in increments of 6 degrees, in specific tests. The standard injection timing was 30 degrees BTDC.

* The concentration of the catalyst in the diesel fuel was altered by employing three different

mixing ratios.

Engine base parameters held constant during the entire test program were compression ratio, and valve timing. The compression ratio was 18:1. Valve timing was set to the engine manufacturers' recommended values for the test diesel as is listed below:

INTAKE VALVE	OPENS 10.8 degrees BTDC
	CLOSES 42.6 degrees ABDC
EXHAUST VALVE	OPENS 7.6 degrees BBDC
	CLOSES 21.6 degrees ATDC
VALVE OVERLAP	= 32.4 degrees

Baseline tests using untreated fuel were conducted at the beginning, middle, and end of the test program to check whether any drift in the engine performance had occurred due to the introduction of the combustion catalyst.

Test Method

The commencement of a new test, with the engine in a cold state, involved a set procedure. This procedure was strictly adhered to. From initial start up the engine was run at part throttle for five minutes, and then slowly brought up to full throttle in thirty seconds. This insured a gradual engine warm-up. The warm-up period was continued until the engine temperature reached 65 degrees C.

With the baseline tests, testing commenced once this temperature was reached and remained stable. Testing of the diesel treated with FPC® catalyst commenced after a engine preconditioning period. The preconditioning or delay period before actual gains in horsepower and fuel economy are witnessed had been observed in previous test programs with the catalyst, and in prior studies by WAIT.

Once testing commenced, the following readings were recorded during all tests:

(1) Brake torque

(2) The time required for the engine to consume the fuel contained in a 48 ml pipette

(3) Exhaust temperature

(4) Ambient temperature

Five readings of brake torque and the elapsed time for the consumption of 48 ml of diesel fuel were recorded at the various speeds. All readings were subsequently averaged and a mean value was recorded.

Discussion

An interesting anomaly was noted at the start of the tests involving the introduction of the combustion catalyst into diesel fuel. The anticipated gains in power output and fuel economy did not occur until after a period of engine running. This anomaly, which had occurred in previous test programs, is often called the engine preconditioning period. Its cause is not fully understood, however a possible explanation will be outlined here.

The preconditioning period may be related to the time required for the combustion catalyst to react with, and slowly remove carbon deposits present on the combustion chamber surfaces. The lack of immediate power output and fuel economy improvement is probably due to the reaction between the active ingredient and the carbon deposits proceeding, instead of the intended reaction between the active ingredient and the diesel fuel. It appears the catalyst may have a greater affinity for pure carbon particles than it does for hydrocarbon molecules and radicals.

Once most of the carbon deposits are removed from the engine's combustion chamber surfaces, the catalyst is free to react with the hydrocarbon molecules and radicals in its normal and intended manner. Gains in power output and fuel economy follow accordingly.

Throughout the Varimax engine test program, engine speed, throttle setting, injection timing, and catalyst concentration in the fuel were all varied to examine the effects of the combustion catalyst on the combustion process. Since the probable mode of action was to increase flame speed, confirmation of this was required in all tests.

Under all engine conditions that tend to slow flame speed, the FPC® catalyst showed greater effect than when the Varimax engine was tested at optimum injection timing, engine speed, throttle and load. Further, as the concentration of the catalyst was increased in the diesel fuel, greater improvement was observed. All of these facts support the theory that the FPC® catalyst effects flame speed. Also, the catalyst will have a more profound impact upon power output and fuel economy in engines operated in the field where transient phenomenon create slower flame speeds, and greater combustion time losses.

Additionally, the observed engine preconditioning period or reaction with existing combustion chamber deposits would be expected to add to the effectiveness of the catalyst under actual field operation since carbon residue tends to reduce the efficiency of an engine over time. Deposit removal from piston crowns, injectors, and ring zone areas, would restore the engine to like-new operating efficiencies.

It stands to reason then, the combined effect of FPC® catalyst removing engine deposits and the speeding of flame propagation when engine operating conditions are more transient, such as in commercial and industrial engines, would cause greater improvements in power output and fuel economy (bsfc).

Conclusions

The Varimax engine test program has shown quite convincingly the benefits of FPC® catalyst in diesel fuel. At the highest catalyst concentration in the fuel, bsfc improvements ranged from 1.71% to 4.99%, with an average improvement of 4.19% at half throttle and low torque, 3.04% at full throttle and high torque, and 2.61% at full throttle, high torque, and 2400 rpm while varying injection timing from 42 degrees BTDC to 18 degrees BTDC.

Even though the test was designed to more closely reproduce actual field operating conditions than was possible in other methods, the engine was still tested at steady-state. Steady-state operation tends to minimize the potential for improvement from the use of a burn rate modifier. FPC® products use under "real life" conditions (transient operation) will create even greater benefits in terms of fuel economy and power output.

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