Fuel Performance Catalyst (FPC) Fuel Additive

Brake Specific Fuel Consumption
Field Test Report

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Overview

A brake specific fuel consumption test protocol was used at Mina la Herradura to measure changes in fuel efficiency resulting from the treatment of a Caterpillar 789C rock truck with the FPC fuel catalyst. The results showed an average improvement of 6.2% in fuel efficiency during normal operational loads.

Introduction

Mina La Herradura is an open pit gold mine located in Mexico's Sonora desert near the city of Caborca and operated by Fresnillo PLC. Ownership is split between Fresnillo (56%) and Newmont Mining Corporation (44%). Mina la Herradura has about 2 million ounces of gold reserves at present and produced 174,000 attributable ounces of gold in 2010.

Test Procedure

Brake specific fuel consumption (BSFC) is a metric that takes into account the amount of fuel required for a specific engine to generate a given amount of mechanical power. To compute BSFC, the rate of fuel consumption and the mechanical power being generated need to be measured. The BSFC is calculated by taking the ratio of these two measurements:

$$Brake\ Specific\ Fuel\ Consumption = \frac{Fuel\ Consumption\ Rate}{Mechanical\ Power\ Generated}$$

The units of brake specific fuel consumption are kilograms-per-horsepower-hour. The units of fuel consumption are kilograms-per-hour. The units of mechanical power generation are horsepower.

The following steps define the test procedure:

1. Instrument an ore truck with the sensors required to measure brake specific fuel consumption.
2. Compute the truck's brake specific fuel consumption using standard diesel fuel and a statistically significant number of data points.
3. Compute the truck's brake specific fuel consumption using FPC-treated diesel fuel and a statistically significant number of data points.
4. Compare the averages from the brake specific fuel consumption results.

Figure 1 shows a picture of the Caterpillar 789C unit that was tested.

Figure 1 – Test Machine

Test Equipment

To calculate brake specific fuel consumption one must measure the fuel consumption and the mechanical power produced.

Fuel Consumption

Flow meters with 0.5% accuracy and 0.1% repeatability are used to measure the fuel flow in the ore truck's supply and return fuel lines.

The volume of fuel changes with temperature. To correct for this, RTD temperature sensors are installed to monitor the temperature of the fuel.

Figure 2 shows the installed flow meters and temperature sensors on the Caterpillar 789C's fuel lines.

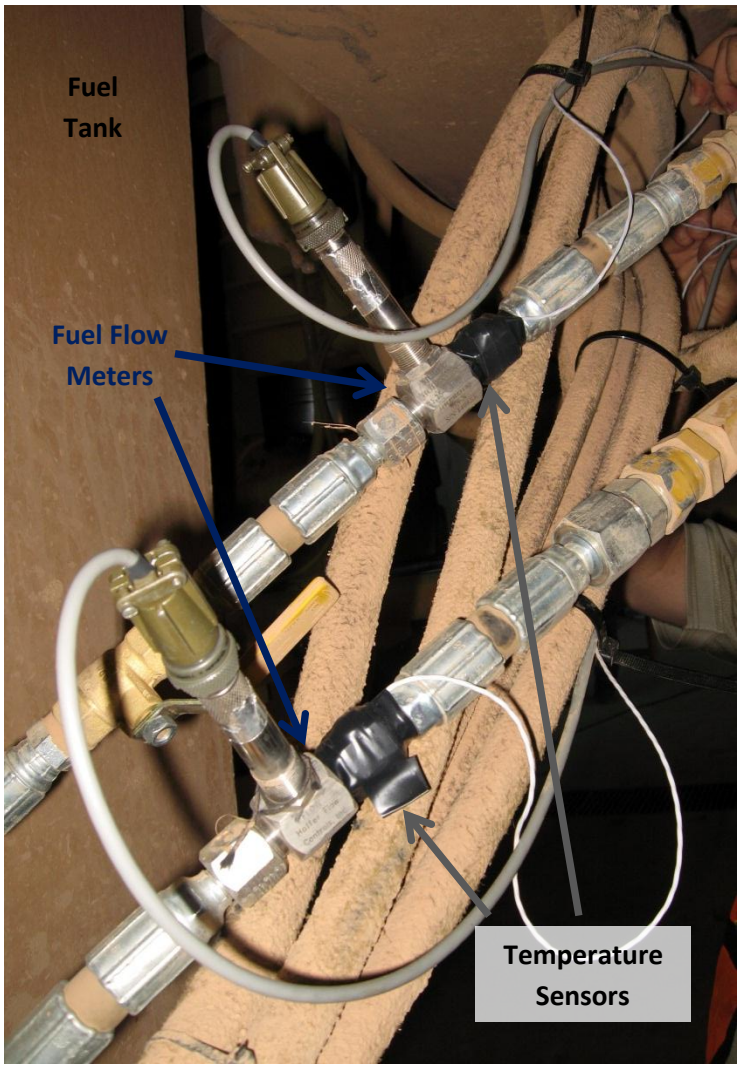


Figure 2 – Fuel Consumption Sensors

Mechanical Power

Mechanical power measured in horsepower is the product of torque and rotational speed (RPM) as given by the following equation:

$$P[\text{hp}] = \frac{T[\text{ft lbf}] \times \omega[\text{rpm}]}{5252.113}$$

A laser tachometer is used to measure the drive shaft's rotational speed in revolutions per minute.

Torque is derived with a strain gauge and a torque telemetry system. The installation of these sensors on the Caterpillar 789C's drive shaft is shown in Figure 3.

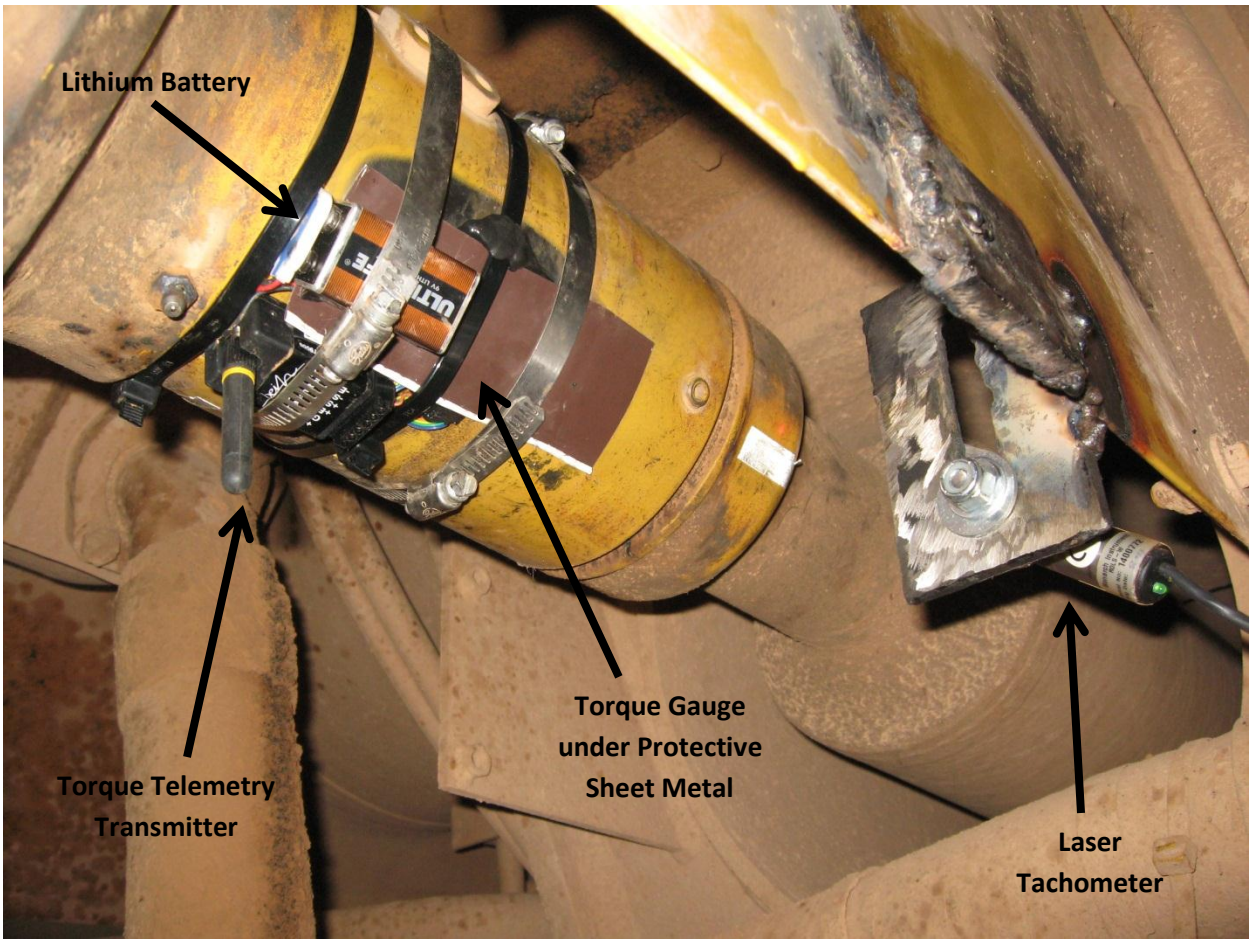


Figure 3 – Torque and RPM Sensors for Horsepower Measurement

Data Logging

A data logging unit was placed in the Caterpillar 789C's cab on the passenger seat. The unit was powered by the 789C's 12 volt auxiliary power in the cab. Wires from the data logger were routed out of the cab and to the fuel flow meters, fuel temperature sensors, tachometer, and the wireless antenna for the torque telemetry system. The unit was configured to collect data every two seconds. Data was retrieved from the unit once a day for processing and to see if the improvement in brake specific fuel consumption was leveling off. The installed unit is shown in Figure 4.

Figure 4 – Data Logger in Caterpillar 789C Cab

Test Results

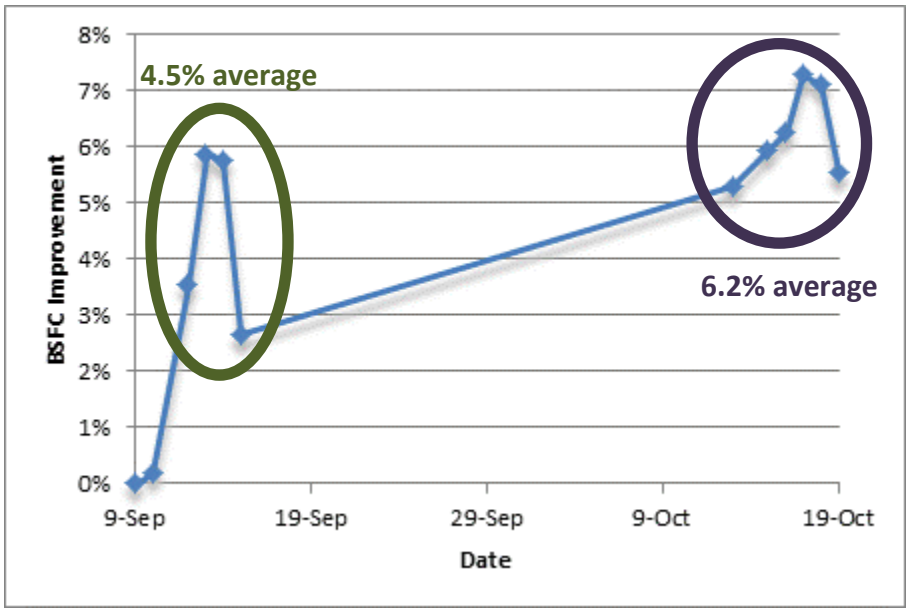
During the testing data was retrieved from the data logger once a day. The raw readings were then corrected for variations in temperature. The normalized data was then used to calculate brake specific fuel consumption. Figure 5 shows the changes in brake specific fuel consumption during the testing.

The first two data points are very close to one another. This suggests that it took about a full day of operating time to consume the untreated fuel in the 789C's fuel tank. After this point the FPC treated fuel would have been in the proper concentration throughout the fuel system.

The four data points that follow show the initial improvement from the catalytic effects of FPC. The average improvement in this group is 4.5%. The variations in the data are typical of results obtained from operating data but show a consistently positive result.

The six data points at the end of the testing would include the benefit from the catalytic effect as well as the cleansing effect that FPC has on the fuel system. The cleansing effect is a gradual improvement that varies based on the condition of the unit under test. It is possible that the BSFC will improve even more with prolonged FPC use. The average improvement in this group is 6.2%.

Figure 5 – Brake Specific Fuel Consumption Improvement over Time



Verification with Engine Control Unit (ECU) Data

Data was captured from the 789C's ECU and compared with the data being recorded by the data logger. Figure 6 shows the readings for engine speed from the ECU and from the laser tachometer used for the brake specific fuel consumption calculation. Figure 7 shows the readings for fuel consumption from both the ECU and the readings from the installed flow meters.

The graphs show that the data from the ECU closely matches the data recorded by the data logger.

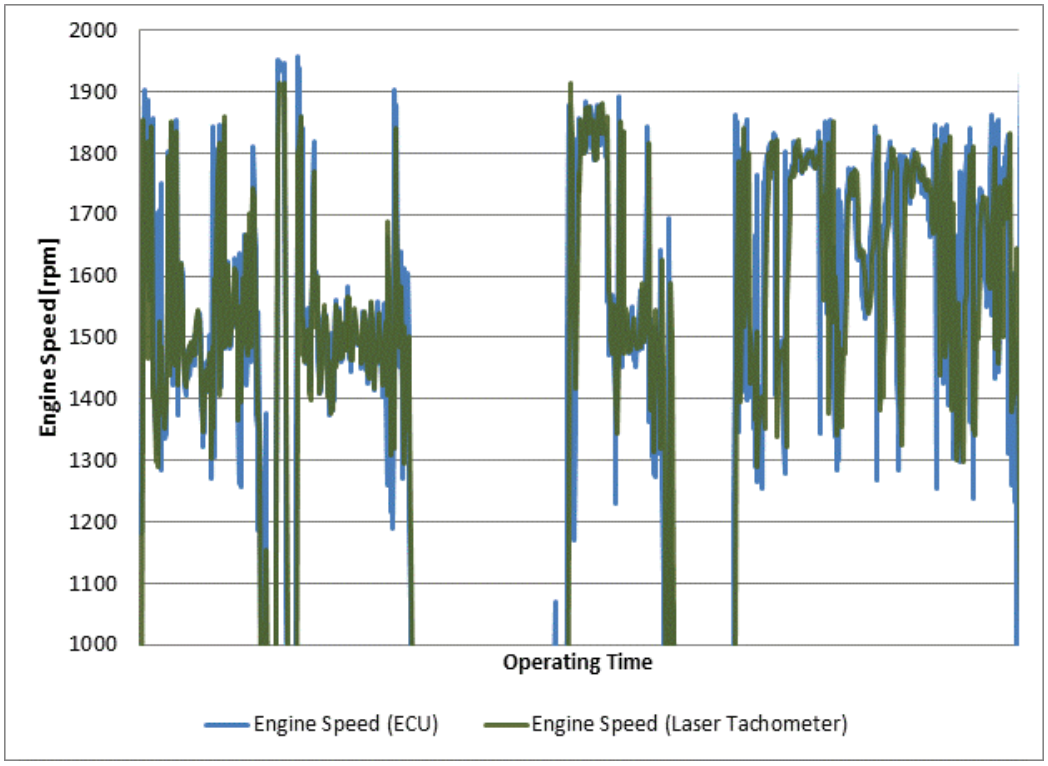


Figure 6 – Overlay of ECU Data and Measured Data for Engine Speed

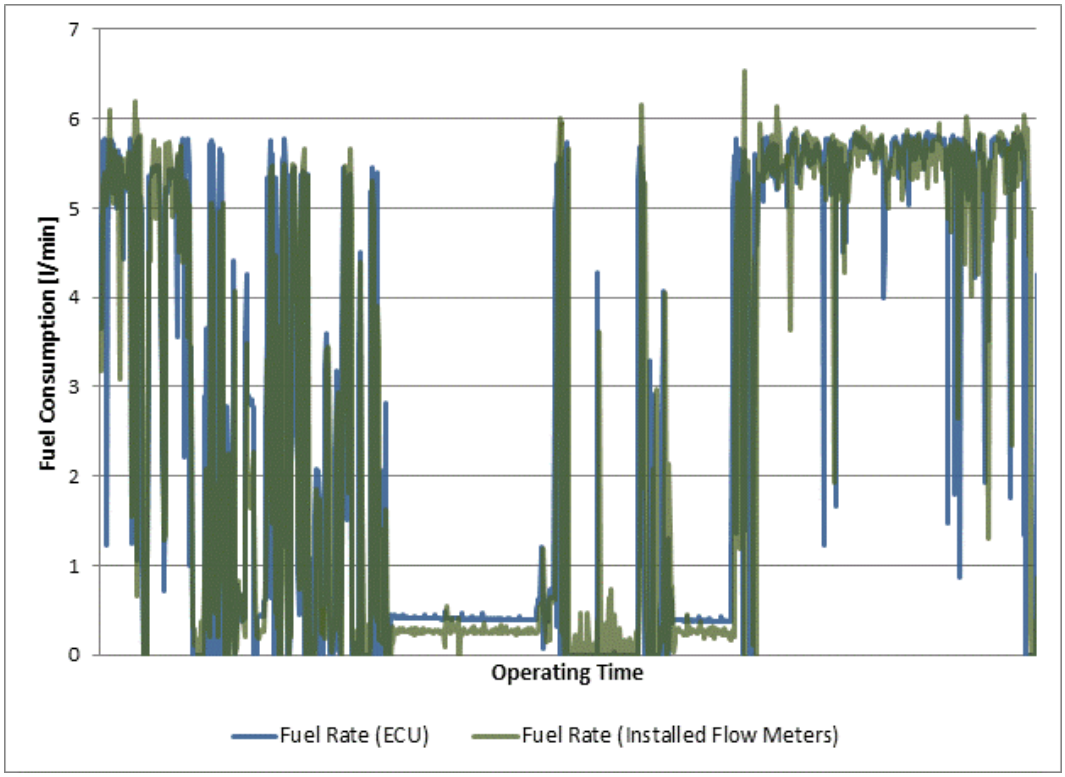


Figure 7 – Overlay of ECU Data and Measured Data for Fuel Consumption

Conclusions

The brake specific fuel consumption testing at Mina la Herradura showed an improvement of 6.2% on a Caterpillar 789C rock truck. This improvement accounts for changes in the fuel consumption of the vehicle as well as changes in mechanical power (i.e. horsepower) produced by the vehicle. This means that the vehicle will need 6.2% less fuel to do the same amount of work. Further, the measurements made during the testing closely matched up with data available from the test unit's engine control unit.