21st Century Locomotive Technology: Quarterly Technical Status Report 17 DOE/AL68284-TSR17

This is the quarterly status report for the 21st Century Locomotive Technology project, DOE Award DE-FC04-2002AL68284. This report covers activities performed January 2007 to April 2007.

Task 1: Advanced Fuel Injection

Objective

Develop and demonstrate an advanced fuel injection system to minimize fuel consumption, while meeting Tier 2 emissions levels.

Progress since last report

Over the first quarter of 2007, we continued engine performance testing with the common rail fuel system on GE Global Research's locomotive single cylinder engine. We showed that further improvements in fuel consumption at T2 NOx values could be achieved with the common rail system. However, we have found that the injection strategies that give the best fuel consumption have the risk of increased PM emissions. Our goal is optimizing the nozzle geometry to maximize the SFC benefit (at constant NO_x level) while maintaining the particulate matter below regulation levels.

Overall, our work over the last quarter has been centered on nozzle optimization for a new piston bowl design. Geometry factors that have been explored include number of holes and nozzle flow. In addition to these geometrical variants, we explored the effect of nozzle needle opening and closing rate.

There are three main accomplishments in the area of advanced fuel injection over the last quarter:

1. Completed study to examine the effect of injector needle raise and fall rate.
2. Investigated the effect of number of nozzles holes.
3. Investigated the effect of flow area.

Some of these results were not conclusive because of an unintended change in nozzle sac volume for some test series. Replacement nozzles are currently being manufactured to repeat selected experiments with the correct nozzle sac volume.

Performed an engine performance study to explore the effect of rate of injector needle raise and fall: By changing geometry details in the fuel injector (needle seat and orifice plate) the needle raise and fall rate can be modified. A study was performed to investigate four different configurations of lifting and falling rate of the common rail fuel injector needle. Trends have been identified as to how the needle raise and fall rate affects the fuel consumption and emissions characteristics.

Investigated the performance effects of different nozzle flow area: The nozzle area was decreased by 10% while all other parameters, including number of holes and spray angle, were held constant. The needle velocity in the opening and closing where also unchanged throughout this study. The study provided insight on particulate matter trends as a function of fuel pressure and nozzle flow area. The results will guide further down-selection and optimization of nozzle geometries.

Investigated the performance effects of number of nozzle holes: The number of nozzle holes was decreased by two while the nozzle flow and spray angle, were held constant. The needle velocity in the opening and closing where also unchanged throughout this study. The study provided insight on particulate matter trends as a function of fuel pressure and number of nozzle holes. Further nozzle hole studies will be carried out next quarter.

Planned activity for next quarter

Over the next quarter, we plan to continue exploring the effects of nozzle geometry performance, but extend our present study by using multiple injections, including pilots and post injections. Bosch is providing a variety of fuel injector nozzles for testing on the single cylinder engine, where the nozzle sac geometry is consistent with the minimum sac volume. Our experimental goal is to down select the best fuel injector nozzle and orifice in conjunction with an optimized multiple injection strategy. The objective with the new piston bowl geometry is to achieve a SFC reduction at the current or lower NO_x level while maintaining acceptable PM levels. Notch 8 is the focus since approximately half of the total locomotive fuel consumption occurs at notch 8.

We will also begin to use an opacity meter in the engine exhaust to characterize smoke in addition to particulate matter mass and particle size distribution.

Task 3: Hybrid Energy Storage

Progress since last report

The battery vendor initiated manufacture of a subscale model battery assembly to calibrate internal pre-stress as a function of adjuster torque. An assembly error was made in manufacturing the subscale model and the vendor committed to make replacement unit expeditiously.