Heavy Vehicle Propulsion Materials

Evaluating Advanced Materials for Heavy-Duty Diesel Engines

Background

Laboratory bench tests are intended to accurately model critical loads that a particular engine component is likely to experience. Experimental results from lab bench tests can be used not only to describe design variations of a component, but also serve as a means to validate the design methodology itself. In this manner, the commercial implementation of materials such as titanium aluminide and silicon nitride as components in diesel engines is planned.

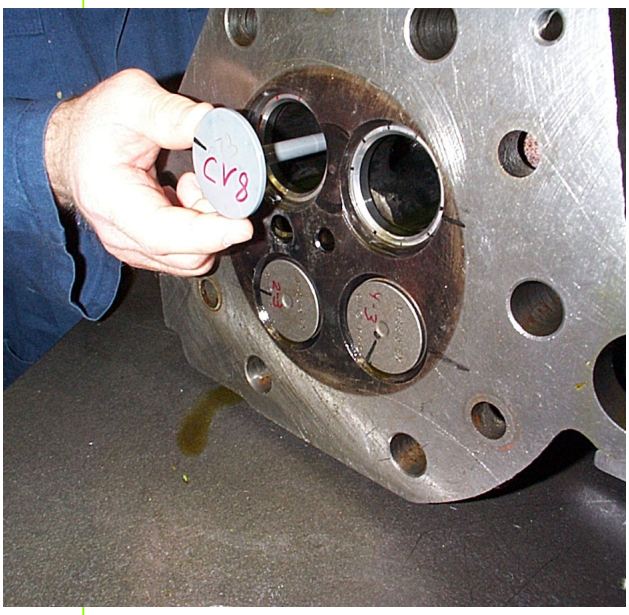
The Technology

A simple and inexpensive bench test has been fabricated to examine the impact and wear properties of engine valves made from silicon nitride and titanium aluminide. This test rig consists of a single cylinder engine head with valve train that is powered by an electric motor and lubricated with a closed loop oil system. The valve tests are conducted at ambient conditions running the valve train at 1800 rpm, 1.5 times the nominal engine speed and for 500-hour durations. Finite-element modeling of the engine valve under these conditions was created and used as input into a design methodology specifically tailored for brittle materials. Service lifetimes are estimated by utilizing strength and fatigue databases generated at ORNL, while nondestructive evaluation (NDE) assessments of the valves before and after bench tests are made at ANL.

Commercialization

The combination of these tasks provides a sound basis for understanding how materials such as silicon nitride and titanium aluminide materials would perform as diesel engine valves. Finite-element modeling illustrates how changes in the valve geometry influence the maximum principle tensile stress, where the failure of brittle materials typically occurs. Modeling of the seating event of the valve against the seat insert has shown the presence of a stress wave that travels up and down the valve stem during the first 200 milliseconds. High-stress regions are identified and are used as feedback in the design assessment. Performing life predictions on the proposed designs has shown that the silicon nitride valve has a low

Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle



Installing a prototype valve into the engine head of the bench test. Valves made of silicon nitride were tested for 500 hours at overspeed conditions to assess impact and wear performance.

probability of failure under these operating conditions.

Future Directions

The same approach will be used for other critical loads applied to the engine valve, such as high- pressure combustion events and modeling the likelihood of the valve making contact with a non-uniform area on the seat insert. The advantages of following this approach will become evident after review of future engine test results using these materials.

Benefits

- Bench test and FEA results correlate the ramifications of component design variations during the impact seating event.
- Probabilistic life estimations for a silicon nitride engine valve were in agreement with impact bench test results.

Where Can I Find More Information?

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