

SwRI EXPERIENCE IN HEAVY-DUTY DIESEL CYLINDER HEAD STRUCTURAL DESIGN

While technologies already exist to extend the PCP limit for most engine component failure modes, the basic cylinder head structural design remains a complicated problem. SwRI has extensive experience in structural design of heavy-duty diesel cylinder heads, with over 70 different modern engine cases analyzed and designed to date. An extensive database of cylinder head structural performance based on an efficient and proven analysis process enables SwRI to take the leadership role in cylinder head structural performance development.



Southwest Research Institute is an independent, nonprofit, applied engineering and physical sciences research and development organization using multidisciplinary approaches to problem solving. The Institute occupies more than 1,200 acres in San Antonio, Texas, and provides nearly two million square feet of laboratories, test facilities, workshops, and offices for more than 3,000 employees who perform contract work for industry and government clients.

**We welcome your inquiries.
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INVESTIGATION OF HEAVY-DUTY DIESEL ENGINE ARCHITECTURE

Southwest Research Institute® (SwRI®) is undertaking an independent research project to investigate design technologies required to extend the peak cylinder pressure capabilities of today's heavy-duty diesel engines. With a target of 250 bar or higher, SwRI's industry-experienced design team will investigate cylinder head structural design concepts that will enable future diesel engines to achieve more stringent emissions levels, while improving power density, fuel economy and performance.

Results of the study will be made available to SwRI clients as an optional phase of SwRI's Engine Benchmarking Program. SwRI expects to play a key role in establishing diesel engine architecture for 2015 and beyond.

BACKGROUND

Heavy-duty diesel (HDD) engines now operate at the highest peak cylinder pressure (PCP) levels of all piston-type engines. Current HDD engines have a practical PCP limit of roughly 190 bar (2800 psi), beyond which adequate structural durability cannot be achieved. The effect of this cylinder pressure limit can be seen on 2004 and 2007 emissions-level engines, which have reduced power density and fuel economy in many cases. To circumvent the cylinder pressure limitation, many manufacturers are increasing displacement to maintain power levels at the new regulated emissions levels.

Typical failures caused by operation at high peak cylinder pressures include:

- ❑ Cylinder head cracking
- ❑ Combustion seal leaks

- ❑ Cylinder block cracking
- ❑ Excessive wear of rod or main bearing
- ❑ Piston pin or piston cracking
- ❑ Crankshaft failure

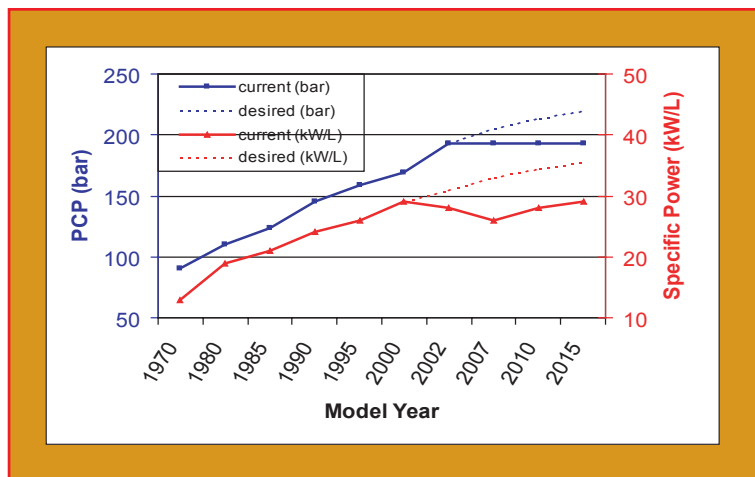
Future combustion technologies, such as Homogeneous Charge Compress Ignition and the addition of higher levels of EGR, create PCP values higher than the current limit, and therefore cannot be made commercially viable until the engine's structural limits are overcome. Higher PCP capability will allow:

- ❑ Increased power density, or HP per liter
- ❑ More power from an existing engine package
- ❑ Increased fuel economy
- ❑ Ability to handle new combustion systems and technologies

EXPERIENCE & CAPABILITIES

The majority of heavy-duty diesel engine industry resources are focused on emissions technology development for 2007, 2010, and Tier IV. More effort is needed to develop tomorrow's engine architecture for improved performance at future emissions levels. SwRI has the technology and experience to address this issue through:

- ❑ Examination, evaluation, and redesign of basic engine structure, with a focus on cylinder head and gasket design and function
- ❑ Examination and evaluation of the effects of emissions and performance requirements on displacement and PCP limit



Current and desired trends in heavy-duty diesel engine-specific power and peak cylinder pressure diverge over time.



Valve bridge failures are common in cylinder heads that operate at high cylinder pressures.