NEW STROKE

JOHN DINKEL describes the triple-event LIM Simple Cycle Engine

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Conventional wisdom and any engine designer will be happy to explain why two-stroke engines are dirty (from an emissions standpoint) and inefficient. Look around. Do you see any two-strokes in America anymore except on motocross tracks and lawns? Throughout the industrialized world the choking fumes from millions of two-strokes powering scooters and motorcycles have led to a ban of these engines in many countries.

So why would LIM Technology LLC, a small tech company in Glen Burnie, Maryland, buck the odds and place all of its credibility and financial resources on convincing you a diesel two-stroke is the next big thing? Because the LIM folks believe they have created the next significant step in the optimization of compression-ignition internal combustion: a clean, powerful, yet fuel-conserving system, in which supercharging (or turbocharging) and new valve technology enable a diesel two-stroke to operate as cleanly as a four-stroke.

Why a diesel? Because it's inherently more fuel-efficient and, using the latest technology, will meet the EPA's new diesel exhaust emissions standards. A 2003 study by MIT concluded a diesel hybrid— not a fuel-cell car—would be the best choice for transportation in the near future. And research by UBS and Ricardo published in May 2007 said: "...conditions may be right for a diesel boom in the U.S.... Diesel's cost burden is lower than [a gasoline] hybrid's for similar fuel economy—even with the 'clean' technologies needed to meet tough U.S. emissions regulations."

In simple terms, a four-stroke cycle consists of intake, compression, power and exhaust strokes. The typical two-stroke "compresses" these four distinct strokes into two and fires on every revolution of the crankshaft, whereas the four-stroke fires on every other revolution. This means a two-stroke is typically more powerful than a four-stroke of equivalent size. But most two-stroke engines are inefficient and are terrible polluters because of the amount of unburned fuel-oil mix escaping through the exhaust port.

Although LIM engines are essentially two-strokes, the LIM process is derived from the four-stroke system, and LIM engines resemble conventional four-stroke engines more than they do two-strokes. Here's why.

In a LIM engine, the exhaust ports are located in the cylinder wall, distributed about its circumference just above the position of the piston crown at bottom dead center. This enables the piston to act as the sole exhaust valve and allows all the valves in the cylinder head to be used for intake only.

LIM readily admits this is not an original concept. Rodi Power Systems, a company no longer in business, built and tested an engine employing similar technology—and it worked well.

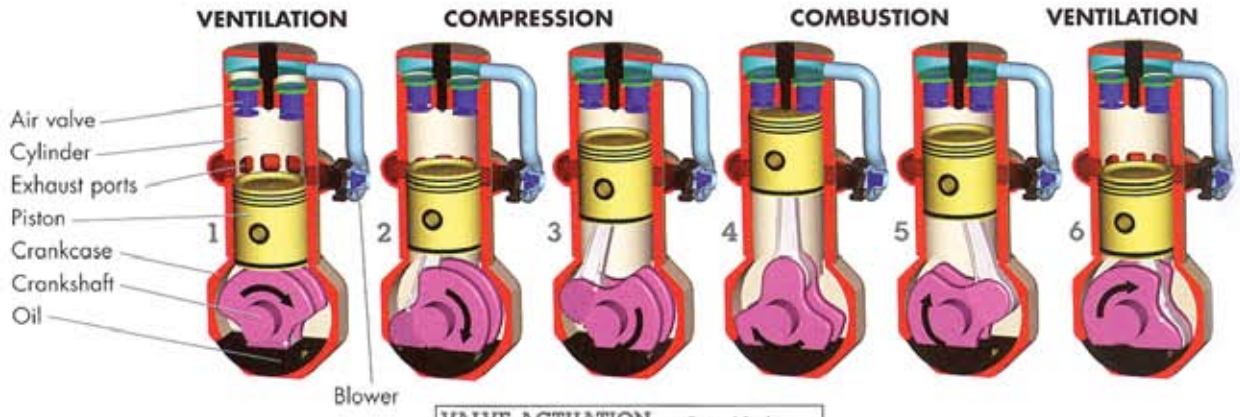
And since the late 1930s, Detroit Diesel marketed engines similar to the LIM and Rodi designs, but with the intake and exhaust reversed: exhaust valves in the head operated by a conventional valvetrain and intake ports surrounding the piston. This design has come to be known as "uniflow."

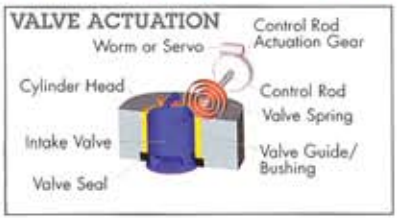
Thus, LIM describes its design and the Rodi engine as reverse uniflow with advantages, including a much cooler head with the potential for reduced NOx emissions and a smaller cooling requirement.

LIM's principal improvement is therefore not the cycle itself, but the simplification of the valvetrain. In a LIM engine, the patented intake valves are powered open by the difference in air pressure. The valves themselves are of a different shape from, and can be less than two-thirds the mass of, any comparable conventional valve of the same material.

According to LIM, its engine can make up to 90-percent more power at a given rpm. With this system, smaller engines can do the work of larger engines and at lower rpm, with less friction, fewer parts, lower fuel consumption and longer oil-change intervals.

If you follow the cutaways (page 24, top), you'll understand why LIM's designers say their cycle is just three events: ventilation, compression and power. As the power stroke ends, exhaust begins, then, almost immediately, new air is forced into the cylinder, displacing the remnants of





We number the cylinder cutaways, above right, 1 to 6, left to right:

1. As the power stroke ends, burned exhaust gases exit the cylinder via the exposed ports above the piston. Simultaneously, pressurized fresh air enters the cylinder via the patented LIM intake valves.

2, 3. Compression occurs as the piston moves upward, sealing off the exhaust ports.

4. As the piston approaches top dead center, diesel fuel is injected.

5. Combustion of the fuel-air mix occurs because of the heat of the compressed air.

6. As the power stroke ends, the exhaust ports are uncovered again, completing the cycle.

Thus a complete cycle occurs in just two strokes of the piston as opposed to four strokes in a conventional engine.

exhaust. This new air is then compressed and fuel is injected as the piston approaches top dead center, completing the cycle.

The mechanical resemblance to a two-stroke is only that the piston acts as the exhaust valve. The major mechanical improvement, compared to a four-stroke, is the use of most of the head area for intake valves, since the exhaust leaves through the ports in the cylinder wall.

The crankcase, as in a conventional four-stroke, is home only to the bearings and crankshaft, the connecting rods and the main lubrication system. Another LIM advantage is the valves need no lubrication, so the main lubrication system does not include the cylinder head, although, if necessary, it could be used to lubricate the compressor.

The compressor (supercharger or turbocharger) is external to the cylinder, but is vital to a LIM-type engine, enabling it to run more like a conventional four-stroke by forcing the fresh charge of air into the cylinder, while simultaneously displacing the exhaust gases.

The cutaway segment of a cylinder head (above) shows the patented LIM pressure-actuated intake valve and its variable-tension spring. In the LIM system, intake manifold air pressure opens the valves. This occurs only as exhaust begins flowing through the piston-managed exhaust ports. It is only when the pressure differential between the intake manifold and the cylinder exerts force on the floor area of the valve, in excess of the spring tension, that the valve can begin to open.

The spring may be manipulated a number of ways. Most efficiently, according to LIM, with a coiled steel tape anchored at the inside of the coil to a control rod. The rod can be rotated to vary the base torsion of the spring and to slightly retard or advance the beginning of valve closing and opening, but the main forces keeping the valve closed are compression and combustion pressure. The more spring force, the later the opening, the shorter the stroke and the earlier the closing.

Another major advantage of the use of the new valves is the superior timing, which enables more efficient trapping of the new air for compression, providing higher volumetric efficiency. Uniflow ventilation is already the best means of scavenging, providing far more efficient cleansing of exhaust remnants than the usual two-stroke loop scavenging.

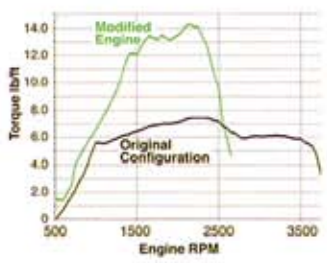
According to LIM designers, material and labor costs to produce a LIM-type engine from the foundry forward will be about 40-percent less than to produce a comparably powerful conventional four-stroke engine.

LIM ADVANTAGE vs. A FOUR-STROKE

Higher torque
Smaller, lighter block
Lower friction
Higher power density
Fewer pistons, cylinders
Shorter crankshaft
No camshaft
No rockers, no push rods
No blow-by gases
Longer oil life
Less expensive
Slower idle
Lower fuel consumption
Lower cost
Power Stroke = 38% of cycle vs. 19% of cycle

COMPARATIVE HORSEPOWER

COMPARATIVE TORQUE



The first LIM test engine was a commercially available, four-stroke single-cylinder diesel. The power and torque curves shown (left) are a comparison between this engine and an identical engine modified by LIM.

The most advanced prototype, with its modern, common-rail, fuel-injection system, is now at TECAT Engineering in Ann Arbor, Michigan. If you are a prospective investor, you can see the engine demonstrated by calling Jeffrey Klein at 410-760- 8801 or by e-mailing him at jklein@limtechnology.com, or by calling Dr. Douglas Baker at (248) 615-9862.