ENERGI

A Norwegian piston engine can be 45 percent more efficient than a modern diesel engine

Odd Richard Valmot Journalist

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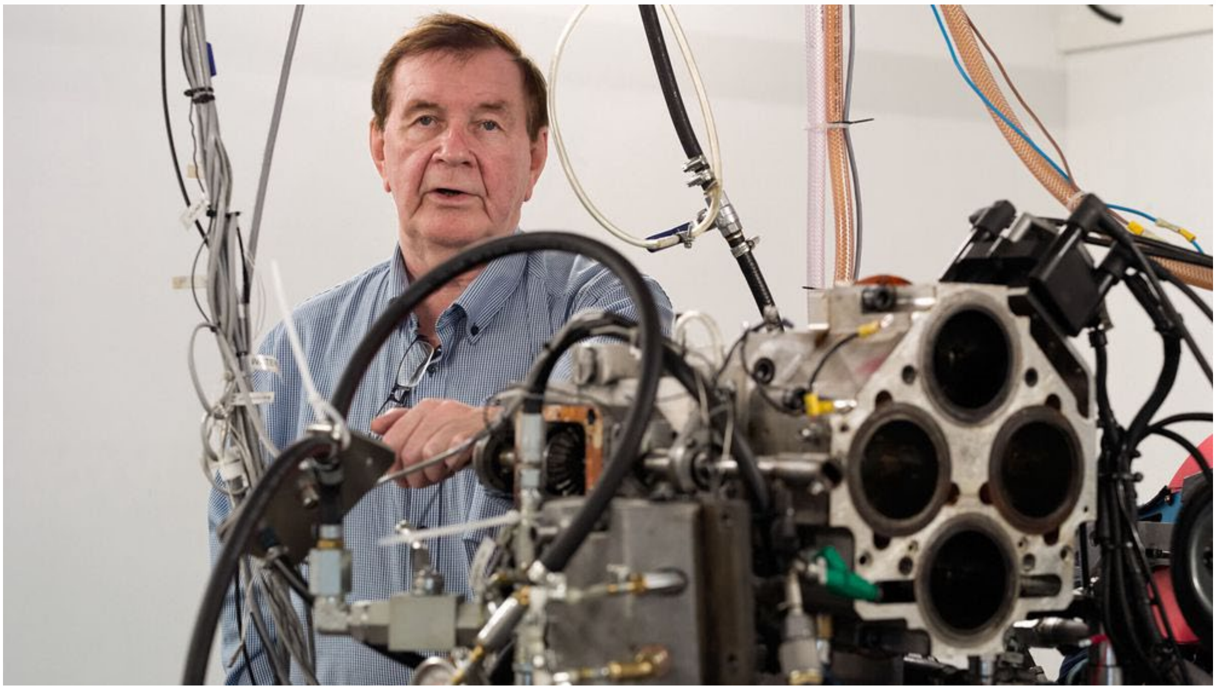
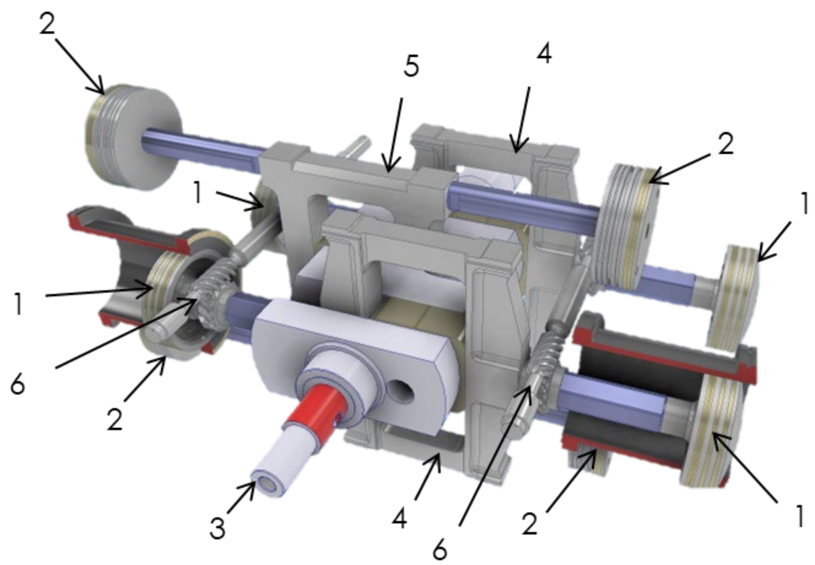
(Unofficial translation)

The piston engine is far from dead. Unfortunately, many el-enthusiasts will probably say. But millions of engines are still being produced for all possible purposes.



Inventor: Hilberg Karoliussen runs the company Patentec. He has a number of inventions behind him already. Now he has set himself the goal of streamlining the piston engine.
Photo:Tom Erik Smedal

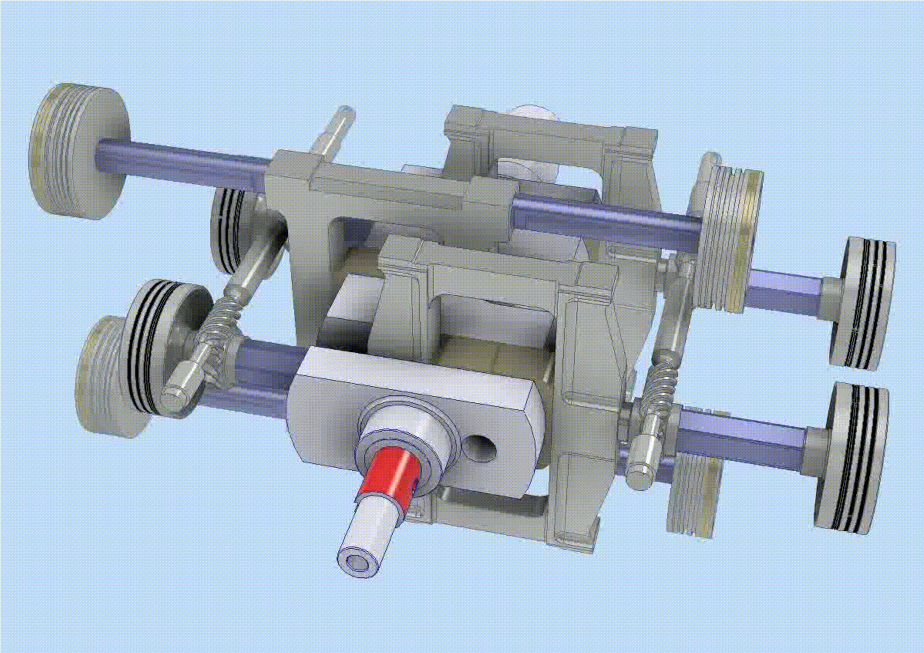
Piston engines, as we know them, make a solid contribution to greenhouse gases when run on fossil fuels. Not least because the efficiency is low. This means that more fuel is needed to do useful work. A diesel VW Golf that runs on a WLTP cycle typically has an efficiency of just under 25 percent. Such an engine rarely runs with a load where the torque is at its peak. There will be a lot of partial loads. And partial load equals low efficiency. Unfortunately, it is not possible to ditch all engines that use fossil energy in favor of zero-emission variants. Therefore, it is value to use engines with the highest possible efficiency so that the fuel consumption per kWh is as low as possible. Modern piston engines cannot regulate part of the important parameters that have a bearing on the efficiency. They cannot regulate the compression ratio and they cannot regulate the degree of filling in the cylinders without throttling the air intake. Also, the traditional engine design causes a significant friction loss between the pistons and cylinders that is impossible to get around. Or can the problem be solved? According to the South of Norway inventor, Hilberg Karoliussen, who runs the company Pantentec, it is possible. He was inspired by the strict Euro6 emission requirements to create an engine that produced much less NOx, but also used much less fuel. The result is an engine with completely linear movements of the piston rods. This has made it possible to solve the challenge of variable compression and to exploit the expansion power of the exhaust gases.



Exploded view: 1 Main pistons (4 pcs) 2 Double expansion pistons (4 pcs) 3 Crankshaft 4 Main yoke (2 pcs) 5 Balance yoke to expansion pistons 6 Variable compression ratio control mechanism Photo: Patentec

The VCR DCE engine (Variable Compression Ratio - Double Compression and Expansion)

Karoliussen's engine, which has recently been checked and verified by DNV, differs radically from a conventional piston engine. But at first glance, it looks a bit like a boxer engine. If we take a closer look at it, however, the only thing they have in common is that two and two of the four pistons work 180 degrees against each other. But that's where the similarity ends. For the pistons on each side are attached to each other on the same piston rod as Siamese twins.

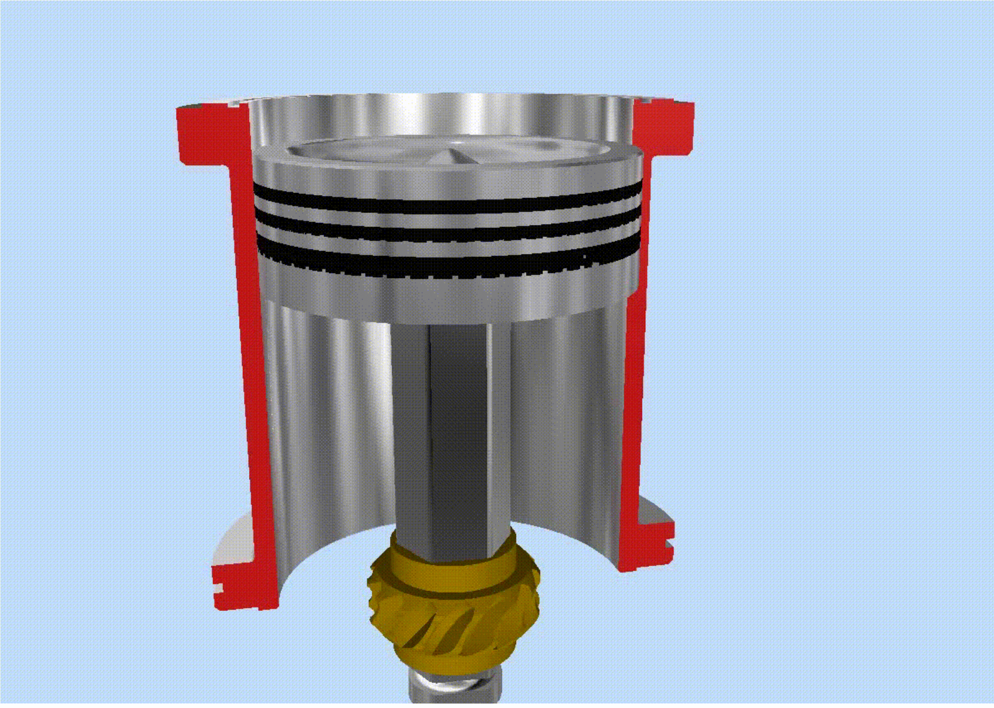


Piston motions

"It's a special engine yes. Our efforts have been to check that it works, and it does. We have observed it running on a gasoline-like fuel for one hour idling. We have not tested the prototype for fuel consumption," says DNV Senior Engineer for Machinery and Systems, Jørgen Eliassen.
To get power from the engine, what is called a main yoke is mounted between the rods. It is a square steel structure that moves back and forth with the piston movements. Yoke is a term that we use for the ring we thread over the head of a horse pulling a cart. There are two such main yokes connected to the working cylinders. Inside these we find the crankshaft and two crankshafts that transmit the force as rotational energy, and that rolls inside the yokes.

Back and forth

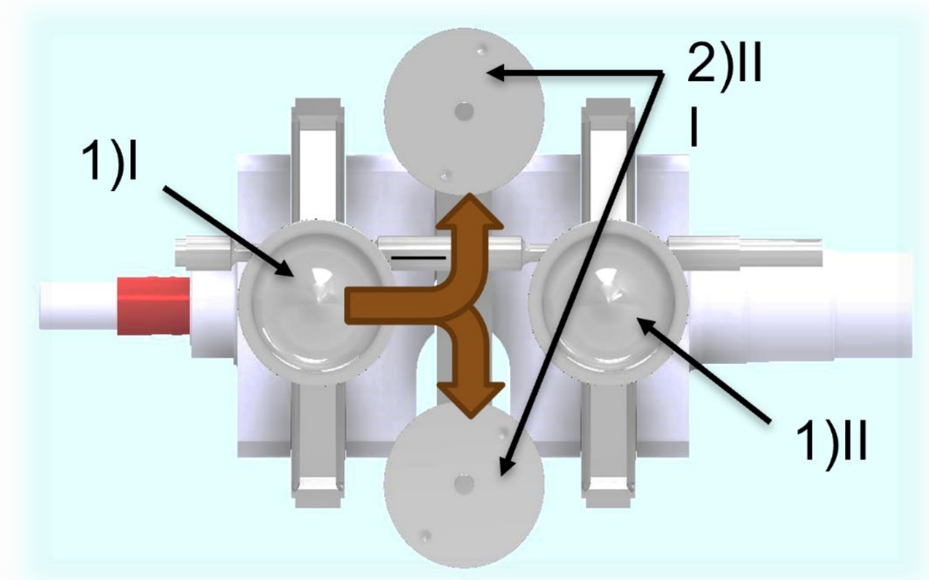
In ordinary piston engines, where the crankshaft that transfers the energy constantly, the piston rod changes the angle relative to the piston. Therefore, the piston will receive a power component that presses it against the cylinder wall twice for each revolution. This produces a friction loss. With a completely linear motion without such lateral forces, such friction loss does not occur. This can be compared to large ship engines that use so-called crosshead technology to prevent such forces in the pistons.



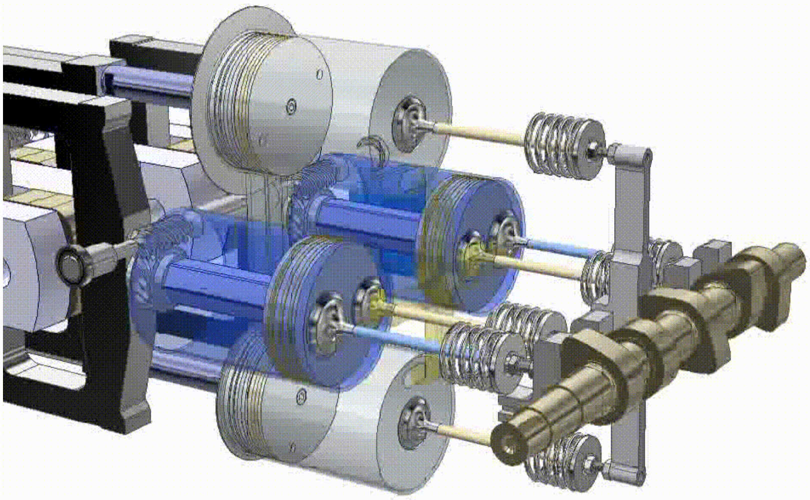
VCR – Variable compression ratio:
Worm gears make it possible to change the compression ratio by lengthening or shortening the piston rods. The balance of the engine is not affected by such changes

The compression ratio is changed simply by lengthening or shortening the piston rods. Two shafts each with two thread pieces intervene on an oncoming threaded piece on the piston rods like four worm gears. They can change the length of the piston rods through a stepping engine at the speed of lightening.

Balance mechanism with an additional job

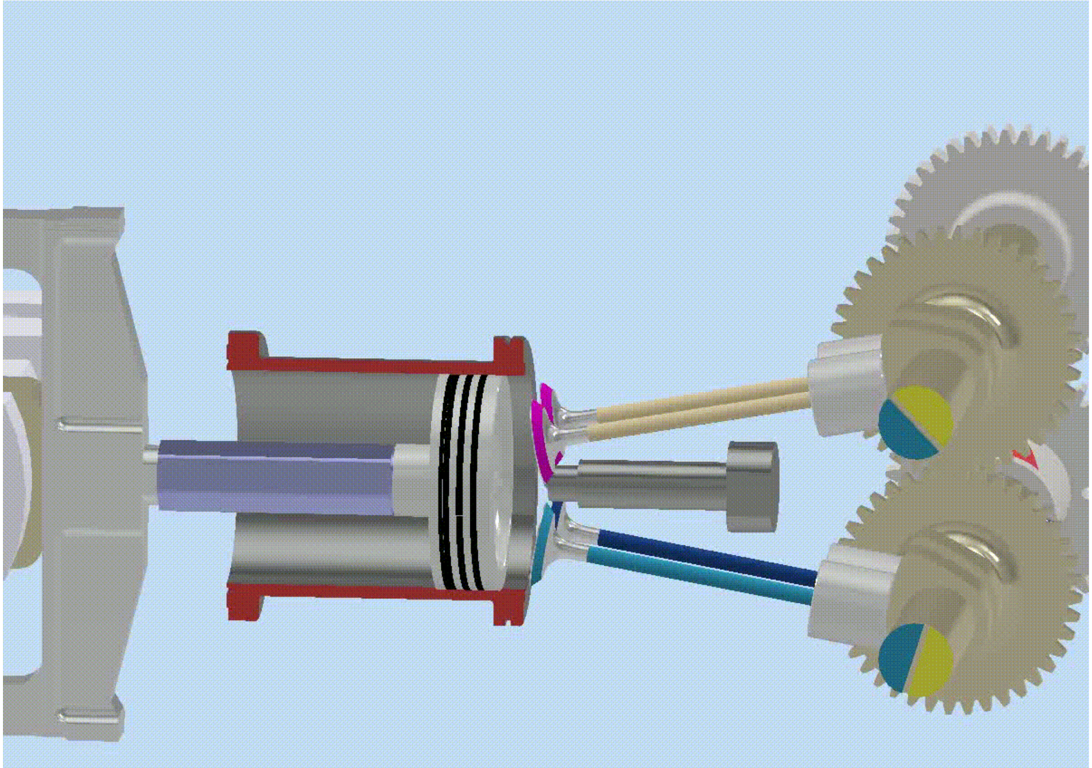


Double expansion: The two double expansion cylinders on one side of the engine (III) work in parallel as one expander. When the expander pistons (2) have reached the top position, the main piston (1) is at the lower dead center and the corresponding exhaust valve opens. The exhaust is then fed from the main cylinder's (I) volume to twice as much volume in the expander (III). The process is repeated after 360 degrees rotation of the crankshaft, but now with exhaust discharged from the second master cylinder (II). Photo: Patentec



Initially, the engine was not completely in balance, like any other piston engine. That's why Karoliussen got the idea to use four additional pistons to do that job. And once they were going into the deisgn, why not let them work a little. So they do. The exhaust is led into these where the hot gas expands further. On the other side of the expansion pistons, they compress air. So they do two jobs. They give the engine perfect balance, and they do the job a mechanical compressor. Much more efficient and cheaper than a turbo. The cylinders that burn the fuel work according to the four-stroke principle, but the expansion pistons act as two-stroke device. In other words, they fetch new exhaust for further expansion for each piston stroke. Each time an exhaust valve on one side opens, two of the expansion pistons are pushed.

Variable Valve Timing

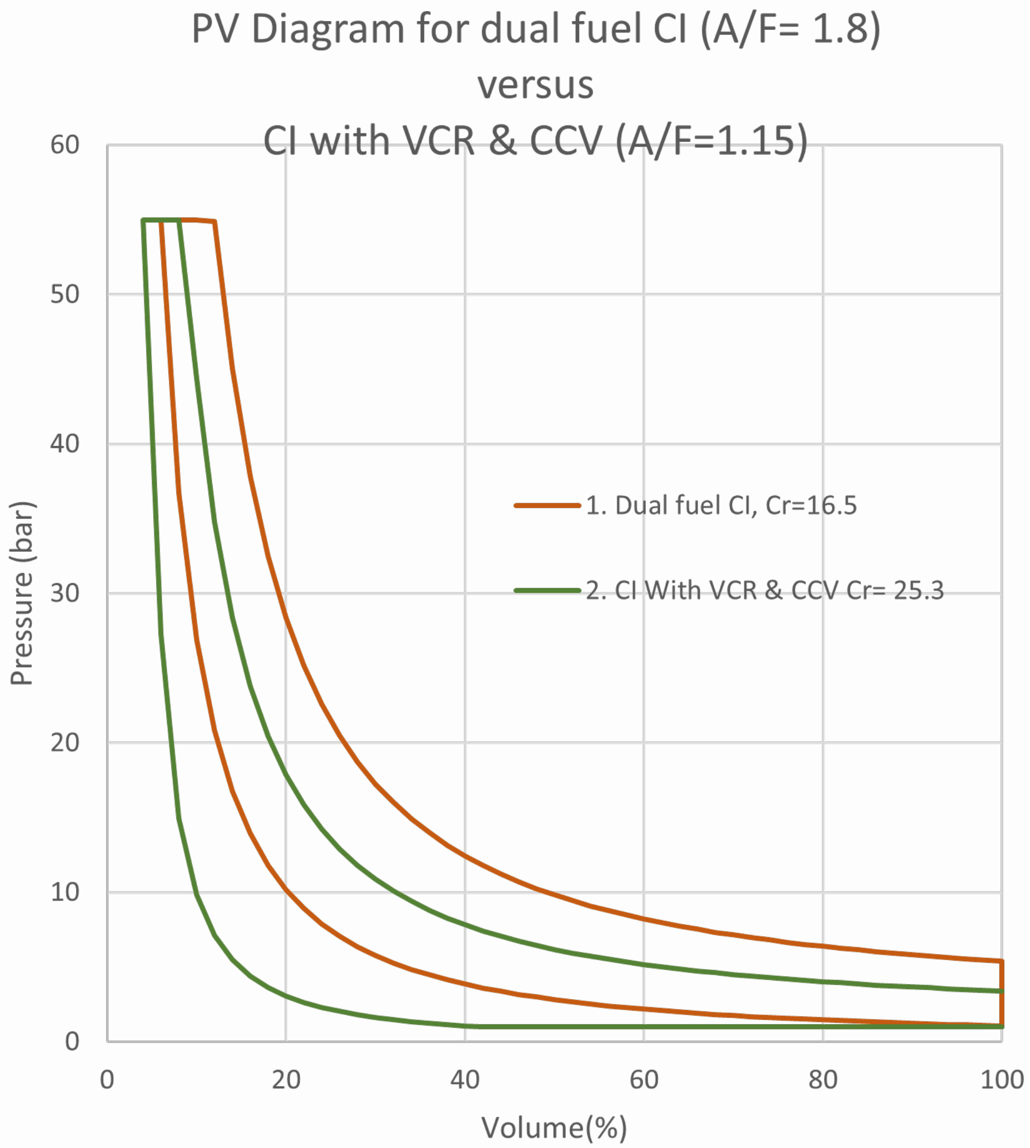


VCR combined with CCV:
Normal compression ratio at high load; The CCV (Charge Control Valve) mechanism operates the intake valves in parallel. Ideal air excess. High compression ratio at low load; The CCV mechanism closes one intake valve late. Still ideal air surplus.

Being able to vary the time the valves in an engine are open is also a way to optimize operation when revs vary. But it's hard. At full load, the valves work as in a regular engine. The two intake valves open and close in parallel. However, at partial load, one intake valve is kept open longer to reduce the degree of filling of the cylinder. This means that the air taken into the cylinder is partially "pushed" out again before compression begins.

Same cost

When the number of parts and complexity are summed up, it will not cost more to produce a VCR DCE motor than a conventional motor. The weight-to-power ratio is between a conventional piston engine and a wankel engine. But the efficiency is significantly better.



Better efficiency: Process 1. shows a P/V diagram for a compression ignited multi-fuel, both diesel and gas, engine running at around 60 percent of full load. This may be the lower limit at which the gas/air mixture becomes too thin. More ignition injection of diesel fuel or disconnection of cylinders is then required to avoid incomplete combustion of gas mixture with air excess as high as 1.8. Process 2. shows how the problem is simply eliminated when CCV reduces the cylinder's charge before compression begins. The variable compression ratio is increased to 25.4 which "compensates" for the reduced charge and late start of compression. By controlling the air/fuel mixture to what is desired, the engine does not need an increased pre-injection or strategy/system for disconnecting cylinders. Process 2 has significantly higher thermal efficiency than Process 1. Photo: Patentec

"It is primarily on partial load that the efficiency is high. That's where engines operate when they're used. We think the efficiency will reach over 30 percent, maybe as much as 35 percent.

That's very much higher than current engines operating in the range of 23 to 25 percent under a standard test cycle (WLTP). At such revs, a lot of power is lost in piston friction in ordinary engines and reduced filling along with increased compression ratio (part load) means optimal conditions for combustion can be maintained, increased expansion and consequently increased efficiency," says engine and fuel expert Knut Skårdalsmo.

"Another problem we can avoid is NOx emissions. Because we can adjust both compression and valve timing, we can control combustion to avoid the high temperatures that generate NOx. Likewise, we can set the parameters so that we burn the vast majority of liquid fuel. It can run on diesel, ammonia or methanol-based fuels. Some of them require a compression ratio of up to 30:1, but such an engine can be optimized in an instant," says Karoliussen.

Nissan gave up

The search for variable compression ratio is not new. It is almost as old as the internal combustion engine itself. In 1920, Harry Ricardo tried a principle to accommodate varying fuel quality, and Nissan launched such an engine a few of years ago. The engine was too complex, heavy and expensive, but uses far less fuel than a conventional engine, despite the fact that it did not have variable valve timing.

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