Innovative Test Bench – Flexible Service

Intelligent Thermodynamic Testing

_____ The thermodynamic test bench from Porsche Engineering is the product of years of testing for a wide variety of customer projects. The thermodynamic specialists at Porsche and their versatile test bench now offer companies in different business sectors comprehensive testing services.

Photos by Jörg Eberl

The new Porsche Boxster being analyzed on the flexible thermodynamic test bench

What was the initial spark for the development of this thermodynamic test bench? It came from a variety of sources: development work on e-mobiles and hybrid vehicles, HVAC (heating, ventilation, and air-conditioning) projects, vehicle cooling systems, and thermal management. Each new task meant new requirements specifications; in consequence, a three-year project working with the test bench became three years devoted to developing the test bench itself. The end result was a very flexible test bench incorporating in-depth testing expertise in the areas of heating, cooling, and maintaining temperatures.

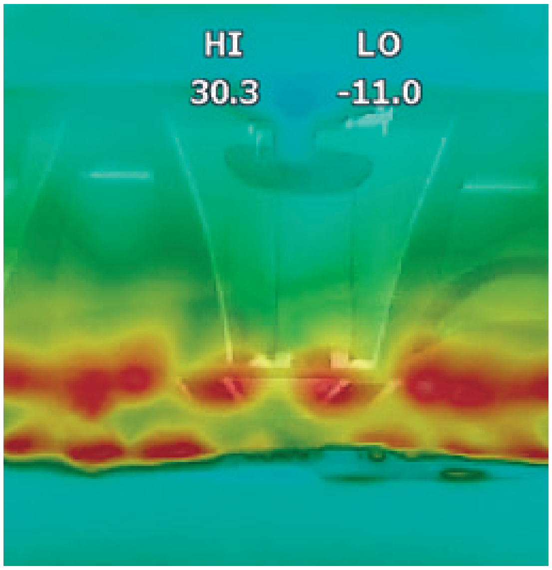
"As an engineering services provider we are offering the Porsche know-how and expertise in the field of thermodynamics to a large variety of customers, who are often confronted with similar problems in their development work," notes Björn Pehnert, development engineer at Porsche Engineering. "Our thermodynamic test bench has been configured for use in various sectors." ›

BOXSTER (TYPE 981): Fuel consumption combined 8.8–7.7 l/100 km; CO_2 emissions 206–180 g/km

One test bench – three media

The test bench offers a demonstration of the options Pehnert is referring to: the test bench conditions air, coolants, and refrigerants with equal aplomb—flexibility available as needed.

All of the systems and components these media flow through can be analyzed on the test bench—and not only in terms of thermodynamics, for the thermodynamic test bench can be connected to a battery test bench as well. For this type of testing, the Porsche engineers simulate the overall vehicle in which the battery would be installed, including any relevant environmental conditions. At the same time that the test battery is loaded as though it were in operation, it is possible, for instance, to represent the complex interaction of cooling and heating, and the control electronics.



The heat distribution is analyzed to ensure that the windshield is defrosted evenly (shown here: the Porsche Panamera)

One test object – hundreds of test points

The thermodynamic test bench is no less accomplished when working alone. All of the pertinent thermodynamic behaviors of a component or system can be tested; depending on the factor and test object, this can add up to 200 test points or more.

The test bench can be run in hot or cold mode, which means that pressure, volume flow rate, and flow behavior can be tested; heat distribution and temperature differences can be tested separately or in combination. On customer request, the test bench can be adapted from R134a refrigerant to its possible replacement, R1234yf. As Pehnert sums up, "The problem itself and how to solve it most efficiently are what guide us in selecting media." One problem that continues to challenge Porsche Engineering customers is the phenomenon of cavitation, which can occur in any component in which there is a rapid increase in the flow rate. In the event of unfavorable pressure and temperature conditions, vapor bubbles can form—and implode—in the fluid. If this happens, microjets strike the inner wall of the component at the speed of sound. Whether we're looking at tubing, heat exchanger accumulators, or cylinder heads, this leads to undesirable results, ranging from the surface being subjected to a high compressive load to its being mechanically damaged. In cases such as these, Porsche Engineering's task is to pinpoint the trouble spots, analyze them, and redesign the flow of coolants so that cavitation can be reliably prevented.

A clear view of hot spots

In order to identify problem spots, the thermodynamic specialists visualize flow processes. One variant that they recommend and implement in the case of extremely short, rapid processes in complex components that are out of sight—cylinder blocks or cylinder heads, for example—is to reproduce the test object on transparent plastic in a rapid prototyping process. Next, the sample part can be flushed with a dyed fluid; a high-speed camera can then be used to film it and capture tens of thousands of high-resolution images per second—and every detail of the flow behavior. When these images are played back over a period of several minutes, even lightning-fast cavitation processes and convoluted flow movements become visible to the human eye, enabling the engineers to document and analyze them.

Demisting and defrosting tests

In case of demisting and defrosting tests the thermography reveals what is essential for cooling, heating, and air-conditioning systems for vehicles: this is the uniform distribution of warm air flowing onto the windshield and into the interior to ensure a mist-free view and rapid defrosting. Here, too, the thermodynamic specialists incorporate a wide variety of customer requests; they adapt individual components—for example, a new dashboard that is to be installed above a preexisting air-conditioning system. Or they might model a complete passenger compartment as a mock-up for the best possible design of the discharge nozzles for all relevant systems.

Full service and troubleshooting

The thermodynamic test bench has been designed with flexibility in mind, and can be combined with an environmental chamber, a vibration test bench, or a shaker test bench. This wide spectrum makes any imaginable type of customer-oriented cooperation possible. “We offer support to companies throughout the development process, starting with the concept and component design; working with suppliers; prototyping and testing; all the way to the start of production,” explains Pehnert. “Or we assist on short notice, for example if individual components need to be optimized before series start-up.”

Energy follows efficiency

Customer projects don’t always revolve around vehicles rolling off the production line. Sometimes the goal is to improve the production: more units produced in less time, no waste, and with low power consumption. The bottom line: fully automated production at the limit of what is technically feasible. This is a challenge confronting companies in a number of business sectors.

Thus, for example, blanks are often heated at the start of a production process; the semi-finished parts or final products are then cooled down at the end. There is generally a historical reason for the separation of industrial heating and cooling cycles, as that was the traditional practice. The Porsche thermodynamic experts are bringing two processes together where they belong: they use heat pumps to collect heat extracted during the cooling process and supply it to the heating unit. And that’s just one example of many energy-efficient solutions from Porsche Engineering. ■

Test bench media in figures

Coolant supply

Type of coolant	Water/glycol
Temperature range	–5°C to +105°C
Flow rate	80 l/min
Cooling efficiency	20 kW
Pressure range	up to 4 bar

Air supply

Temperature range	–5°C to +80°C
Volume of air flow	1,000 l/s
Cooling/heating efficiency	20 kW
System pressure	45 mbar at 1,000 l/s
Upstream flow cross-section	800 mm x 500 mm

Refrigerant supply

Type of refrigerant	R134a
Temperature range	–10°C to +10°C
Refrigerating capacity	0 kW to 15 kW

A thermodynamic test bench for a variety of customer requirements

Available media

> Air
> Refrigerant
> Coolant

Available test procedures

> Cold-water testing
> Hot-water testing
> Demisting/defrosting tests

Flexible use

> May be coupled to an electric test bench
> Modular integration with other test benches is feasible

PANAMERA: Fuel consumption combined 12.5–6.3 l/100 km; CO_2 emissions 293–159 g/km