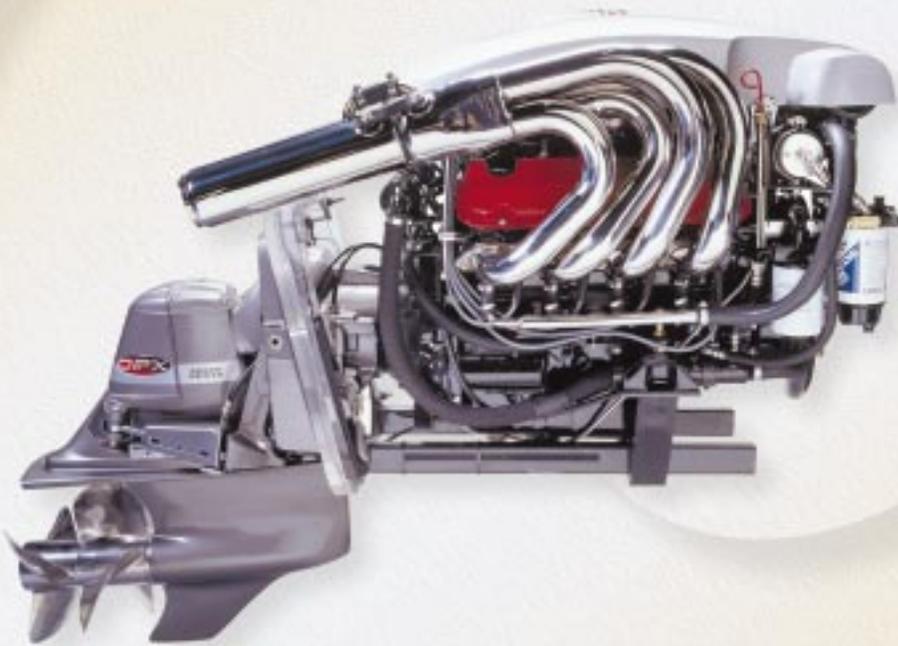


**OPTIMUM**  
Power Technology

**IGNITES**

**Volvo Penta's**  
**Engine Performance with**

**Virtual 2-Stroke**  
**and Virtual 4-Stroke**



**VOLVO**  
**PENTA**



## OPTIMUM POWER TECHNOLOGY

**W**hether for business or pleasure, a boat at sea demands unfaltering engine and equipment reliability. Because the engine is the heart of a boat, providing power means more than just propelling the vessel – it also means operating navigational aids and systems, winches, pumps and other on-board auxiliary equipment. With so much at stake, **Volvo Penta** of the Americas, a global manufacturer of technically advanced power systems realizes it is critical to not only ensure engine reliability, but to also meet worldwide environmental standards. That's why **Volvo Penta** utilizes Virtual 4-Stroke and Virtual 2-Stroke engine simulation software from **OPTIMUM Power Technology** of Pittsburgh, Pa. to maximize power and reduce the emissions of its 4-stroke and 2-stroke engines.

The product line in **Volvo Penta's** Marine Leisure and Commercial Marine business segments comprises gasoline and diesel engines of 10 hp to 770 hp, plus complete drive systems and accessories. The Industrial Engines business segment offers engines and drive systems for many different applications – everything from generator equipment to propulsion systems.

According to Dr. Douglas Hahn, *Director of Engine and Reliability Engineering* with **Volvo Penta**, "We specialize in providing engine designs for marine commercial, leisure, industrial, or racing applications. Each of these areas requires different engine criteria. For example, the goal for a race boat may be to get just one race out of the engine, requiring high horsepower over a short period of time. Leisure craft may require medium horsepower with 1,000 hours of reliable engine performance, while commercial craft may require low horsepower with 3,000 hours of engine performance. Whatever the performance criteria, we rely on Virtual 4-Stroke and Virtual 2-Stroke software to ensure our systems are engineered to achieve the highest levels of horsepower and torque without sacrificing 'driveability' and potential harm to the engine."

*"The ultimate benefit of using Virtual 4-Stroke and 2-Stroke technology is that we save a significant amount of time and, ultimately, thousands of dollars in prototyping."*



— Dr. Douglas Hahn, *Director of Engine and Reliability Engineering* with **Volvo Penta**

## PREDICTING AND ANALYZING ENGINE PERFORMANCE

Because engine design is often a compromise between conflicting requirements, **Volvo Penta** relies on Virtual 4-Stroke and Virtual 2-Stroke technology to provide complete and reliable assessment based on:

- *Performance* – Power, Torque, Indicated and Brake outputs
- *Emissions* – CO, HC, NO<sub>x</sub>, Fuel and Air Consumption
- *Efficiency* – Charging, Trapping and Delivery Ratio
- *Combustion* – Angle of Peak Pressure
- *Noise* – Intake and Exhaust Sound Pressure Level Spectra

Prior to using engine simulation software from **OPTIMUM Power**, **Volvo Penta** relied on predictions of engine performance, such as horsepower and torque based on other modeling techniques. All of **Volvo Penta's** design research and development, prototype builds and testing are done internally to ensure total quality control and unsurpassed attention to detail. The design work, engine prototyping, and testing are done at **Volvo Penta's** offices in Chesapeake, Va., then sent to the Lexington, Tenn. plant where the manufacturing and production testing are conducted using a dynamometer (Dyno).

“The ultimate benefit of using Virtual 4-Stroke and 2-Stroke technology is that we save a significant amount of time and, ultimately, thousands of dollars in prototyping,” said Dr. Hahn. “The software enables us to see wave dynamics within the engine itself so we can quickly fine-tune performance in the design stage. For example, we can run several camshaft analyses within hours, as compared

to the several days it would take through standard Dyno testing. For these reasons, we believe Virtual 4-Stroke and 2-Stroke are the most accurate and user-friendly wave dynamic software packages available in the industry today.”

Another benefit of Virtual 4-Stroke and 2-Stroke technology is that it enables **Volvo Penta** engineers to model specific horsepower and torque output curves that can later be compared to Dyno outputs. “This engine simulation technology helps us determine theory versus reality. We can predict engine criteria such as fuel economy and engine power to satisfy a particular market need. We can show a simulation curve, for example, then overlay the Dyno curve to ensure our predictions match. This not only controls quality, but also provides us with unique skills in implementing engineering technology and tailoring these installations to the varying needs of individual craft.”

*Animation and Pressure Wave Action throughout Engine*



**VOLVO  
PENTA**

*"...we achieve maximized power from our designs, while also ensuring that our engines discharge lower emissions into the environment."*

— Dr. Douglas Hahn,  
Director of Engine  
and Reliability  
Engineering with  
Volvo Penta



## ENGINE SIMULATION BACKED BY GLOBAL EXPERTISE

One of the key reasons **Volvo Penta** chose to implement Virtual 4-Stroke and 2-Stroke technology was due to the expertise and responsiveness of **OPTIMUM Power Technology**. After nearly a decade of development and close collaboration with The Queen's University of Belfast, **OPTIMUM Power** has released its own proprietary engine simulation software products. The theory underpinning the simulation code was developed and tested at Queen's and is explained in numerous technical papers and two textbooks written by Professor Emeritus Gordon P. Blair.

"We are confident in **OPTIMUM Power's** technology due to the high level of expertise of the software development team and their own successful racing efforts," Dr. Hahn said. "**OPTIMUM Power** is very responsive to our needs and we know they have the technical knowledge to help ensure our engine simulations generate results in our final designs."

With Virtual 4-Stroke and 2-Stroke software in use for over a year, **Volvo Penta** continues to enjoy the competitive advantages this engine simulation technology provides. As Dr. Hahn summarized, "One of our cornerstones is that all products should not simply meet quality, but should surpass customer expectations in order to maintain long-term relationships. Virtual 4-Stroke and 2-Stroke technology is an important part of this formula in that it helps us design and build technically advanced power systems that provide users with such a high level of performance that they are totally satisfied with their choice both now and in the future. From a competitive standpoint, we cannot ask for more than that." ❖

### ACHIEVING 'OPTIMUM POWER'

The inability to understand how and why an engine performed as it did can limit the value of simulation. Virtual 4-Stroke's and 2-Stroke's flow visualization and data manipulation capabilities enhance the designer's intuition about what is really happening inside the engine.

"We can visualize flow through the engine and attached ducting using animation, which is an invaluable tool in designing tuned intake and exhaust systems," said Dr. Hahn. "We can also investigate key thermodynamic properties at every stage of engine operation, including pressure, temperature, mass flow, species, or Mach number. The software makes it straightforward to plot any of these parameters against one another for comparison and reporting purposes for one or more engines."

Together, the powerful simulation features of **OPTIMUM Power's** software enhance the performance and reduce the emissions of 4-stroke and 2-stroke engines. "The software has a host of post-processing applications that display and animate simulation results to help us make successful design decisions," Dr. Hahn explained. "As a result, we achieve maximized power from our designs, while also ensuring that our engines discharge lower emissions into the environment."



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