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Porsche **Engineering** Magazine

A sound foundation:
State-of-the-art materials and technologies are used for the Cayenne bodyshell.

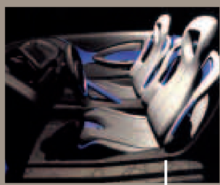
Cruiser powered by Porsche:
Porsche Engineering collaborated with Harley-Davidson in developing their water-cooled V-Rod engine.

Porsche styling:
Virtual reality has become an indispensable tool for design studios.

The Porsche Engineering Group GmbH (PEG), a subsidiary of Dr. Ing. h.c. F. Porsche AG, is responsible for the sports car constructor's global contract development activities.

Porsche is the only car manufacturer to make its extensive engineering knowledge available to international customers from various sectors. In conjunction with its domestic and foreign subsidiaries, the Porsche Engineering Group provides expertise on a global scale in the fields of automotive engineering and transport under the Porsche Engineering banner.

In so doing Porsche Engineering has access to the resources of more than 3,000 engineers from construction, prototype, production planning, procurement, logistics and production divisions.



Dear Readers

The start of a new year is always a good time to reflect on the accomplishments of the past year. Porsche Engineering was privileged to work on many challenging projects in 2002, and we would like to take this opportunity to thank our clients for the trust they placed in us.

Surely one of the most noteworthy events was the successful completion of our collaboration project with Harley-Davidson to develop the Power Cruiser V-Rod. The engine/transmission unit, one of the Cruiser's highlights, was developed jointly with Porsche Engineering.

We will face new challenges in 2003, but the Porsche Engineering Group is ready to meet them head on.

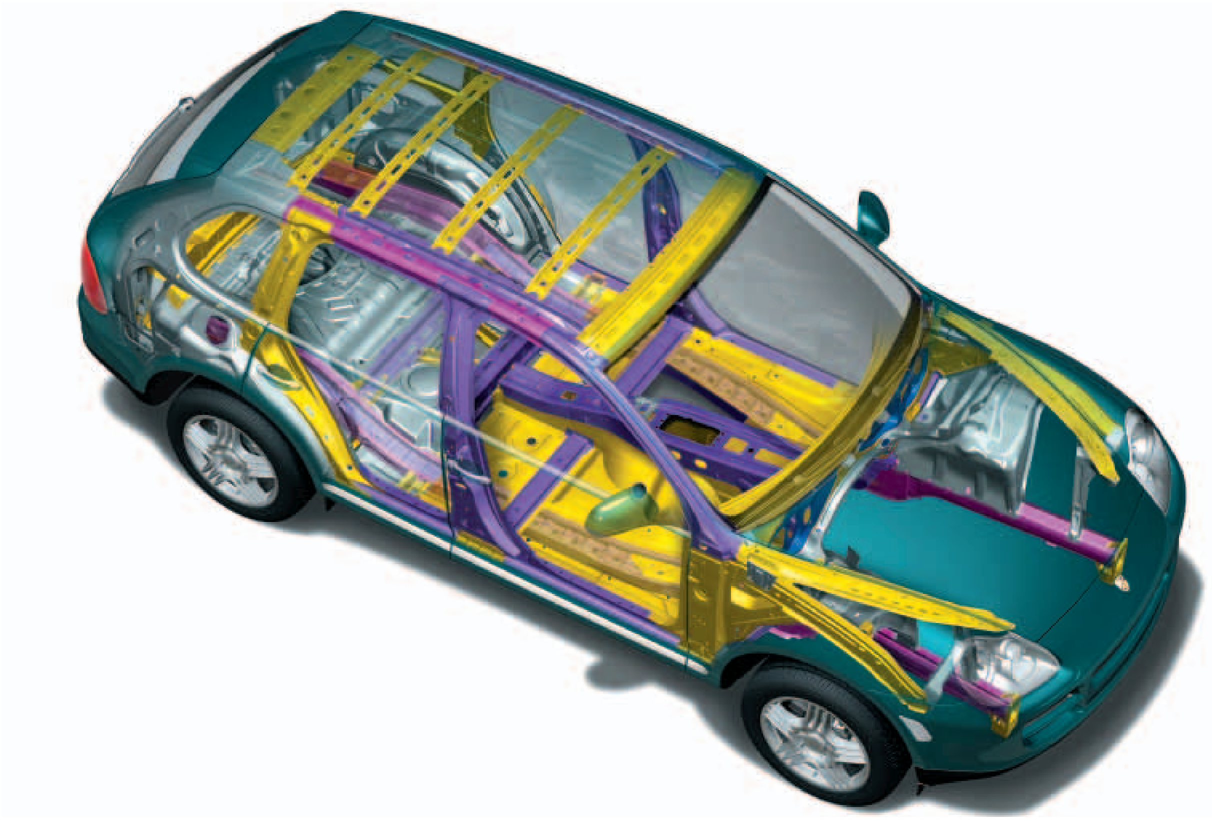
In developing the Cayenne, we have perfected many new technologies and ideas that we can now offer to Porsche Engineering clients as well.

We have added a number of highly qualified employees to our team in the Electrical/Electronics division. Our “Porsche Speech Technology” is just one of the exceptional solutions we are offering in this promising sector.

We wish you a successful year 2003 and enjoyable reading.

Your Editorial Team

A sound foundation: the bodyshell of the Porsche Cayenne



Bodyshell of the Cayenne Turbo under the vehicle skin

The bodyshell of a high-quality Sports Utility Vehicle must meet high demands and greatly outperform the structure of a pure sports or off-road vehicle. Thanks to the use of modern materials and technologies, the Cayenne demonstrates exemplary driving characteristics both on and off the road and simultaneously meets the very strict Porsche safety requirements. The Cayenne thus underscores Porsche's competence in the field of lightweight steel construction.

Body concept

In the initial design phase of the Cayenne, Porsche first examined the two types of bodyshell construction that are conventionally used for Sports Utility Vehicles. With the classic solution, the bodyshell is mounted on a separate ladder frame. The innovative alternative is a unitized body. The advantages of the two concepts were determined by simulation so that they could be combined when designing the Cayenne's structure: a unitized body with integral frame. Engineers firmly integrated the frame into the floor assembly and

Platform and frame forestructure

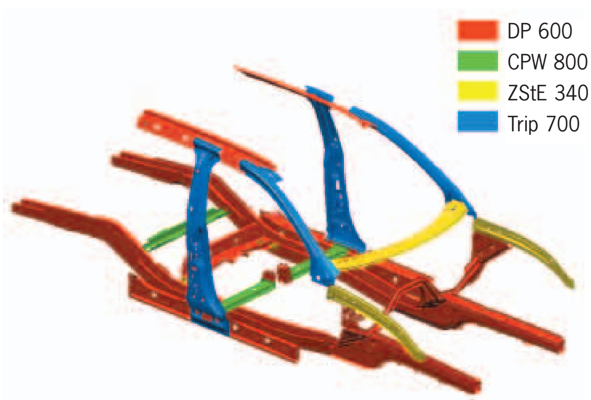
designed structural members that run along the entire length of the vehicle, passing underneath the floor panel in the area of the passenger cell. This arrangement with straight structural members is particularly advantageous when it comes to absorbing crash loads. All axle and equipment mounting points are located in the continuous side members. With this concept, the side members shield the functional parts and equipment and thereby protect them from damage during demanding off-road use.

The remainder of the bodyshell structure on the floor assembly is modular. The frame forestructure with structural members, shock towers, web plates and brackets completes the platform, to which the preassembled sidewall assemblies are attached in the first step.

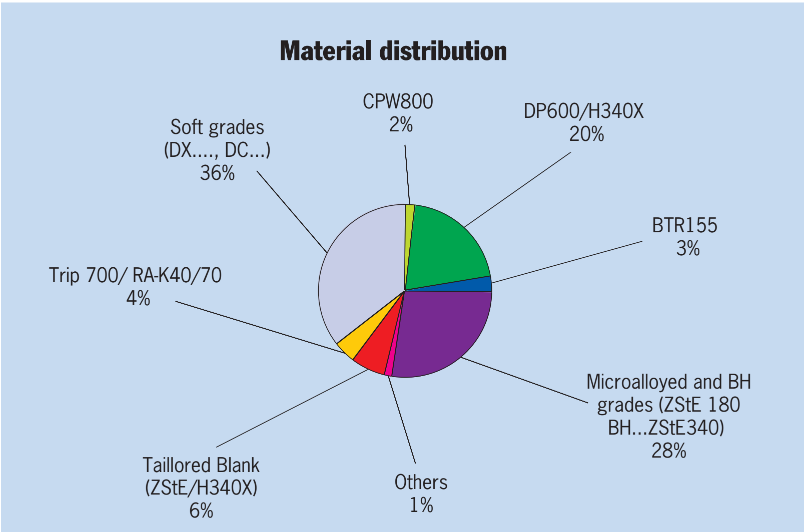
The sidewall section, comprising the inner and outer A, B, C and D-pillars, plus the side portion of the roof frame and the outer wheel housing, is affixed to the floor panel, roof cross-members and end panels and then welded in place. This modular design principle, which was selected early on in the development process includes the definition of the assembly sequence and direction. The necessary separation levels between individual modules and the new mounting concept, positively influences the dimensional stability of the bodyshell and thus also the functional reliability of adjacent components.

Material concept

The Cayenne bodyshell is a shell-type structure consisting of double-sided galvanized sheetmetal panels of various thicknesses. When they defined the material concept, the Porsche engineers consistently applied the knowledge they gained from earlier projects and studies concerning mechanical parameters and deformability. A large portion of the vehicle's load-bearing structure consists of DP and TRIP steels,



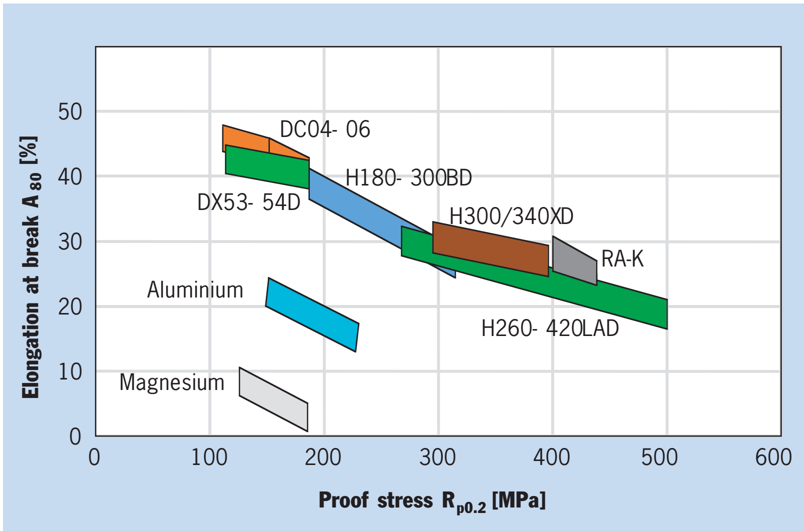
Load-bearing structure of high-strength and super-high-strength sheet-steel materials with yield points higher than 340 MPa



Materials used in the bodyshell

which have very good work-hardening properties. Their high energy-absorption capacity and strength make them the ideal materials for the deformation areas of the body and for the rigid passenger cell. By contrast, panels such as the floor panel, roof and sidewall are manufactured from softer steel grades with good deep-drawing properties.

Porsche decided to use the most suitable type of steel for each part of the body, taking the load, the manufacturing, and joining methods into account. Therefore 64 percent of the body consists of high-strength and super-high-strength steel materials.

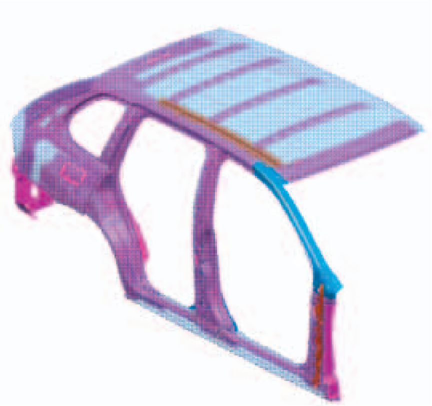


Strength and elongation values of materials used in the bodyshell

This makes the Cayenne the world's first series-production vehicle in its class to incorporate such a large amount of multi-phase steels in its structure (DP: dual-phase steels, TRIP steels, CPW: complex-phase steels). With these innovative materials, it was possible to develop a rigid body that meets the strictest safety standards and is simultaneously lightweight (392 kilograms without doors and lids).

Innovative joining methods

The joining methods appropriate for each specific material and load are used for the Cayenne's bodyshell. These methods include MIG brazing, MAG welding, resistance spot-welding and laser welding. The number, position and length of joining elements were optimized in an iterative process with the aid of numerical simulation methods. The use of multi-phase steels alone required extensive studies to determine the best joining method. The evaluation of metallographic and quasi-static tests showed that multi-phase steels can be joined with high process reliability using MIG brazing, MAG welding, resistance spotwelding and laser welding, provided that the electrode forces are adequate during spotwelding. Cyclical tests on standardized specimens verified that multi phase steels can achieve similar endurance properties under shear loads to those of soft deep-drawing steels.



Bodywork and roof

The technological “pièce de résistance” among the joining methods used for the Cayenne is the laser-brazing process for the roof seam. It was possible to exploit all of the advantages offered by laser brazing, i.e. a nearly rework-free and tight connection that can be produced at a high process speed and with good repeat accuracy.

Passive safety

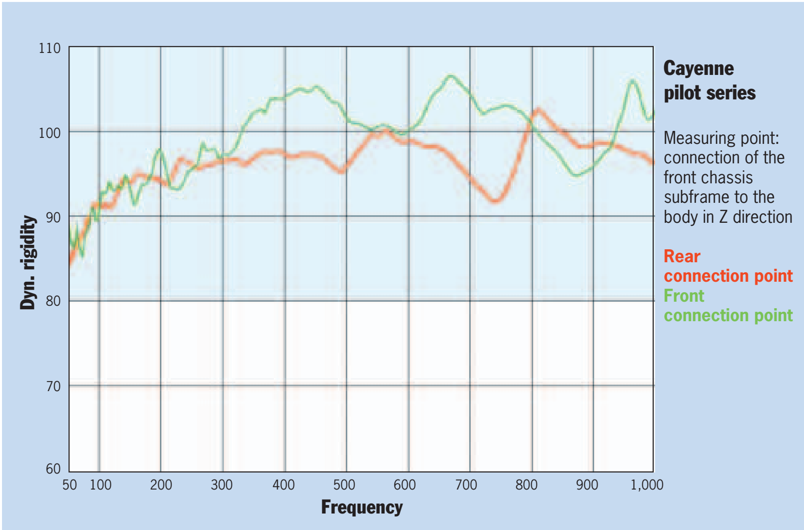
Taken together, the structural, material and joining concepts have produced a bodyshell with a rigid passenger cell offering a high level of protection against intrusion. Deformation zones at the front and rear protect the passenger cell. The straight side members and the high-strength material in particular make a substantial contribution to the passive safety. They deform in a specific manner without local buckling in frontal and rear-end collisions, absorbing the lion's share of the kinetic energy. Another technological highlight protects occupants in side impacts: the sill is strengthened by a super-high-strength reinforcement tube made of BTR 155 seamless drawn tubing, which has a tensile strength of 1,400 to 1,800 MPa. It runs along the entire side of the vehicle between the front and rear wheels and is supported on the side members and tunnel. Forces occurring in a side impact are absorbed by seat cross-members of CPW 800

The high static torsional rigidity of 36,900 Nm/° gives occupants a feeling of safety and solidity, even when one wheel is hanging in the air.

steel, which are welded transversely into the structure and connect the reinforcement tube to the tunnel. This arrangement and the extraordinary strength of the components also protect the passenger cell in side impacts and, in combination with energy-absorbing door trim panels and curtain airbags, keep the biomechanical occupant load values low.

Static and dynamic rigidity

Loads produced by off-road use and fast, agile driving on the road place special demands on the body's rigidity. A rigid bodyshell conveys a sense of solidity and safety to the occupants while simultaneously providing a comfortable ride. Even under maximum torsion load during off-road driving, e.g. when one wheel loses contact with the ground, all doors and the tailgate of the Cayenne can still be opened and closed without difficulty. Another positive effect of high rigidity is the relatively slight relative movement between add-on parts. As a result, trips on uneven roads are very quiet.



Dynamic rigidity plotted against frequency for the front and rear front-axle bolting points

Special emphasis was placed on the safety and rigidity of the lightweight steel structure for the Cayenne from the very beginning of the development process, and this also facilitated the realization of requirements that usually have a negative impact on the structure. These requirements include concealed tailgate hinges and gas springs. Cleverly designed components and component separations made it possible to compensate for the geometric disadvantages and allowed for ideal integration of the components into the rigidity concept for the area surrounding the tailgate aperture.

The same applies to the prepared reinforcement points, which allow special equipment items such as the external spare wheel or the trailer hitch to be attached with little additional effort. These reinforcements also strengthen specific parts of the structure and thereby increase the static and dynamic rigidity at the body nodes.

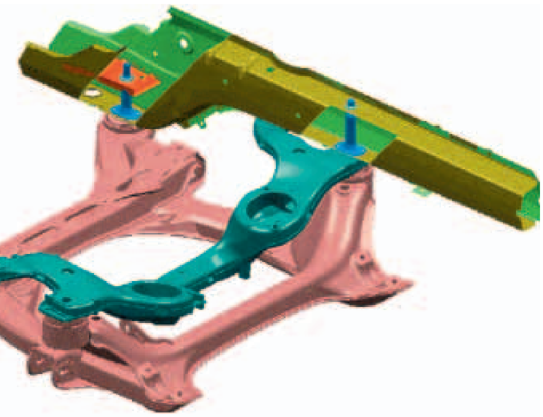
Connection of the trailer hitch to the bodyshell

With its optimally designed sheetmetal parts and appropriate joining methods for the area around the tailgate aperture, the Cayenne achieves superior dynamic rigidity values.

Realization of all of the measures developed in the concept phase through to production readiness has given the Cayenne a static torsional rigidity of 36,900 Nm/°, a superlative value in the segment of Sports Utility Vehicles.

The development team also strived to give the Cayenne's bodyshell an optimal dynamic rigidity and therefore initially concentrated on the design of the sheetmetal parts and joining methods for the area surrounding the tailgate opening. It had to reach a compromise here between visibility, loading width, tailgate hinges, concealed gas springs, the requirement for large cross sections and ideal transitions.

As many components as possible were integrated and structural adhesive bonds were used in the overlapping areas in order to increase the resonance frequency. For example, the ultra-high-strength reinforcement tube was integrated in the lateral sill structure to the lasting benefit of both the static and dynamic rigidity values.

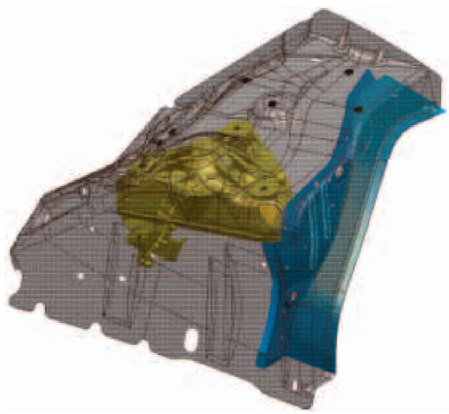


Connection of the chassis subframe to the body at the front

The values of 43.6 Hz for the first torsional resonance frequency and 50.3 Hz for the first flexural resonance frequency are currently among the best in the sector of Sports Utility Vehicles and are comparable to those of luxury limousines.

Structure-borne noise and interior sounds

High local dynamic rigidity at the points where loads from the chassis, engine/transmission unit and exhaust system enter the body forms the basis for good insulation of structure-borne noise. This insulation keeps rolling or engine noises away from the passenger compartment and minimizes the noise level in the interior. The mounting elements for the engine and transmission subframe were specially adapted to prevent them from producing disturbing driving and engine noises.



Suspension-strut mounting and bracket

This fine-tuning forms the basis for achieving good driving dynamics, comfortable vibration damping and a long service life, even during demanding off-road driving.

The type of chassis subframe attachment to the body provides the necessary local dynamic rigidity for the Cayenne. The challenge here was to reconcile the conflict between the acoustic parameters and the weight when it came to the relationship between the dynamic rigidity and the frequency for the front and rear front-axle bolting points, the reason being that these characteristics are directly related to the mass.

This problem was solved by connecting the necessary reinforcements and brackets to the existing load-bearing structure to provide all-round support. With a rectangular cross section of the structural members, the force-introduction bracket is connected to both webs and both chords.

The upper and lower flange plate zones of the force-introduction points are the most highly stressed parts in the body during vehicle operation.

Endurance strength therefore plays an important role in addition to the acoustic requirements. This design solution with brackets welded on all sides produced high local rigidity and good insulation of structure-borne noise combined with minimal weight gain.

Sealing, coating, corrosion protection

Another highlight in the third model line from Porsche is the car's wading ability: a Cayenne with steel suspension can cross bodies of water up to 500 millimeters deep without difficulty; this value is as high as 555 millimeters with the air suspension. The floor area of the vehicle lies significantly below the 500-millimeter line for reasons of convenient occupant entry and exit. To provide effective protection for the passenger compartment against water penetration, the sill is closed to the outside and open to the inside. The continuous side member runs parallel between the sill and tunnel and, unlike the sill, is open to the outside and closed to the inside. If water should condense

Bodies of water up to 555 millimeters deep are no problem for the Cayenne with air suspension.

Extensive sealing of the vehicle prevents dust from penetrating into the interior, even after long periods of driving on dusty roads.

in the closed sill, it can be drained through a specially developed water drain valve without impairing the Cayenne's wading ability.

Underbody openings required for catholic dip-coating of the body cavities are sealed with special plugs. These plugs are heat-bonded to the body by means of a melting ring. A so-called double sealing concept was realized for the underbody area of the Cayenne. With this concept, the seam seal of each spotwelded flange is supplemented with adhesive sealant. The separate joining and sealing levels were required due to the innovative joining methods used, e.g. laser welding. Adhesive seams with a length of around 120 meters in total are used in the Cayenne. Adhesive sealants, structural adhesives and strength adhesives are used.

Besides double-sided galvanized steel panels and extensive surface-protection measures, cavity sealing also ensures the car's extraordinary longevity. On the Cayenne, cavities are sealed by means of so-called wax flooding: cavities are filled with wax and then drained again. This provides better wax penetration into hard-to-reach gaps compared to conventional spraying methods.

This extensive sealing of the vehicle also has another positive effect: the Cayenne is virtually “dustproof”. The interior and occupants are protected, even after hours of driving on dusty unpaved roads.

Acoustics are our forte

A dummy with an artificial mouth simulates speech while recording the interior acoustics.

Communication units play an important role now that most European countries allow drivers to telephone at the wheel only if they use hands-free equipment. Porsche Speech Technology (PST) meets the challenge of satisfying users' high quality demands – including when it comes to sports cars, of course.

Not much has changed for the user since the invention of the telephone. It is still necessary to hold a microphone as close to the mouth as possible and to position a loudspeaker right next to the ear, and this is no different when telephoning from a car. However, greater comfort and safety demands on the part of users and statutory requirements call for complex solutions where cars are concerned. Hands-free telephony and operation of the systems should be possible by means of voice recognition. It is the goal of Porsche Speech Technology to design and optimize voice systems to permit telephone conversations even in a difficult environment, such as in a convertible.

Hands-free telephony is seldom easy

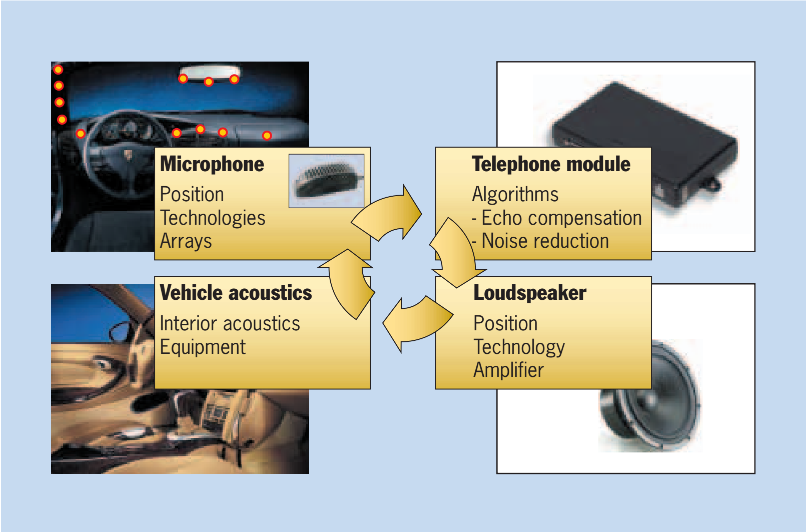
Legislative prohibitions mean that the ideal situation, in which the microphone is placed in front of the mouth and the loudspeaker is located directly beside the ear, is no longer possible for drivers in most countries. Achieving the best possible speech quality despite these restrictions requires appropriate modifications to the interior equipment.

Integrated microphones and the loudspeakers of the audio system now replace the handset. However, driving noises and echoes (feedback loops) can seriously impair the transmission quality. Speech quality depends on all components in the telephone chain. This chain begins with signal acquisition by the microphone, which is closely linked with the momentary acoustics in the vehicle. This is followed by signal processing in the telephone module and output via the loudspeaker.

Acoustic speech quality is a key aspect for users. The driver usually has no trouble understanding the person he is talking to, but that person often has difficulty comprehending the driver. This problem becomes abundantly clear when one person tries to interrupt the other.

Objective measuring technologies are the basis for optimization

An objective measuring method in a laboratory is the prerequisite for specific analytical optimization of hands-free equipment. An artificial speaker and the ability to record the sound field in the vehicle form the basis for ensuring reproducible telephone conversations.



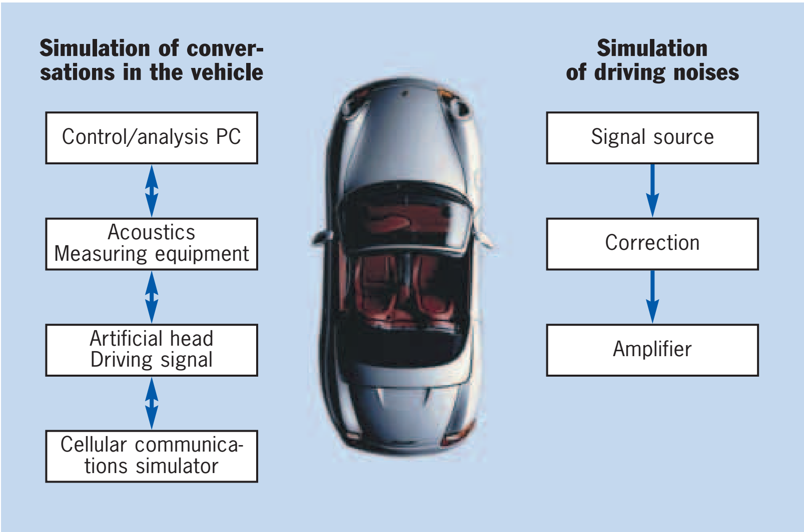
All links in the telephone chain influence the overall speech quality.

PST uses an artificial head with an integrated artificial mouth for these measurements. This setup can be used to produce reproducible speech or test signals and simultaneously record the interior acoustics. The reception quality of the communications link fluctuates in real-life operation. Independent measurements therefore require a network simulation of the cellular communications link in question. This is the only way to realize simple control over various parameters such as the field strength.

PST evaluates the recorded telephone conversations and test signals in the Porsche acoustics laboratory. Signals can be listened to and analyzed offline in the sound studio.

Simulation of driving noises

Since the real difficulties in voice communication arise when the vehicle is being driven, a means of simulating authentic driving noises in a stationary vehicle is needed. This type of noise simulation can be used to recreate different driving situations, including trips at varying speeds or acceleration processes, for example. Furthermore, driving noises from other vehicles can also be added to the simulation. This lets sound engineers confront the system of a limousine with the driving noises of a sports car, for instance.



Simulating conversations in combination with different vehicle noises allows targeted quality improvement.

Quality analysis and component check

The study findings are viewed and evaluated within the context of signal theory. Various analysis methods can be used to test the quality and discover possible deficiencies.

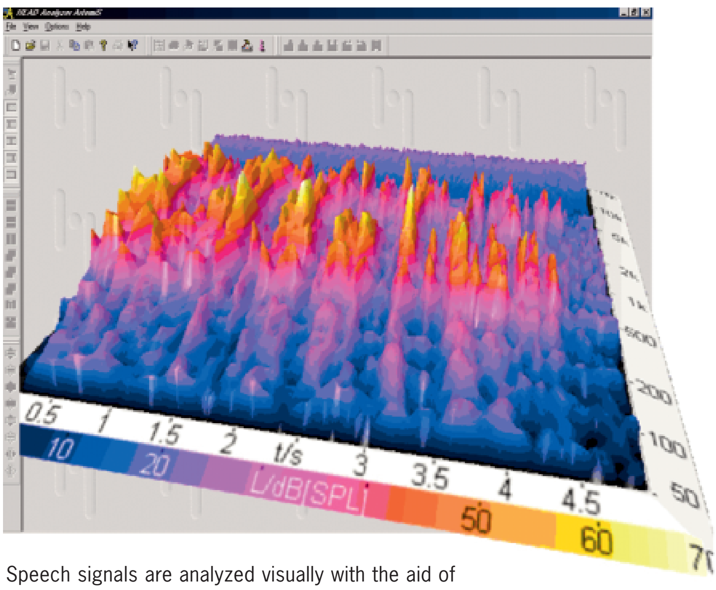
Test results are documented using existing standards, e.g. the VDA specification pertaining to hands-free equipment.

The measuring equipment used by Porsche Speech Technology is also capable of testing individual components as early as the vehicle development phase and can also document the progress made. For instance, it is possible to influence the acoustic layout of the vehicle interior or determine the optimal microphone position in a targeted manner.

Voice recognition matched to the vehicle acoustics

The use of a voice-recognition system in a car requires precise adaptation of the system to the car's acoustics. In comparison to hands-free telephony, additional special parameters such as the recognition performance or fault tolerance have to be observed for voice-recognition applications. Here too, noise simulation and the measuring equipment can be used in a stationary vehicle.

Porsche Speech Technology is highly versatile: applications range from observing components or examining complete telephone systems in the vehicle to implementing and fine-tuning voice-recognition systems in the acoustic environment of the car. This allows speech quality to be optimized at all development stages of a vehicle. ■



Speech signals are analyzed visually with the aid of virtual representation.

Cruiser developed with Porsche Engineering

When Harley-Davidson decided to develop a completely new motorcycle, it also broke with several long-standing traditions and took the bold step of adopting state-of-the-art technology for high-performance engines.

Porsche Engineering collaborated with Harley-Davidson in developing the Power Cruiser V-Rod.

A number of innovative and forward-looking solutions were developed in collaboration with Porsche Engineering, one highlight being the drivetrain.

Until now, all series-production motorcycles from Harley-Davidson have been powered by air-cooled two-valve pushrod-type engines with a vee angle of 45 degrees. These parameters have changed radically for the V-Rod. The new engine, based on the VR 1000 racing engine, features four-valve DOHC cylinder heads, bucket tappets, water cooling, staggered cylinder banks with 60 degrees vee angle, a multi-disk oil-immersed clutch and wet-sump lubrication. The drivetrain and transmission will be introduced here as an example of the overall development.

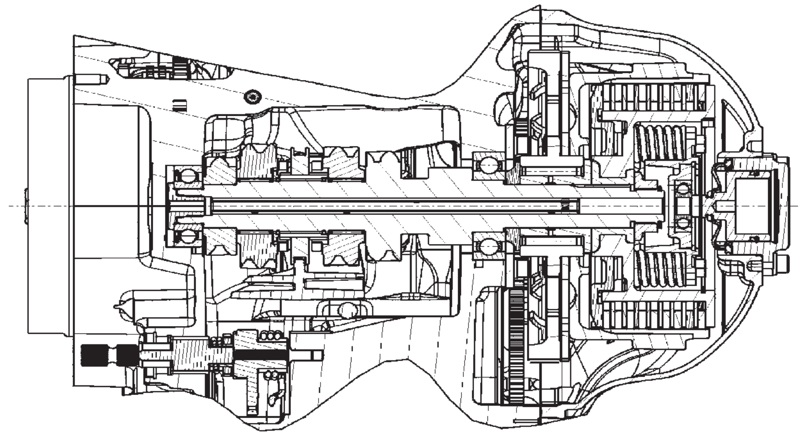
Clutch and drivetrain

As in most motorcycles, engine, clutch and transmission of the V-Rod are accommodated in a single housing. The housing is split horizontally, and the crankshaft and the transmission input and output shafts are positioned perpendicular to the direction of travel in the parting plane of the housing. The transmission with gearshift mechanism is located at the rear of the housing. Oil is supplied by a wet-sump lubrication system.

The vehicle concept chosen for the V-Rod has a decisive influence on the clutch design. This motorcycle's long wheelbase, its low center of gravity and its high front-wheel load allow even occasional motorcyclists to achieve very high initial acceleration values. There is no danger of a wheelie with the V-Rod, even under extreme acceleration.

A maximum acceleration value of up to 1.3 g was attained for brief periods in tests. A value which only very few motorcycles can match. This acceleration capacity requires a clutch that can cope with the high demands involved. Comparison tests have shown that the clutch-engagement times and speeds and the engine loads of high-performance racing motorcycles are much lower than the values for the V-Rod. However the wheelie tendency of these motorcycles limits their acceleration capacity. Not so for the V-Rod: with this motorcycle, the gear can be engaged at maximum engine speed and full throttle without the front wheel lifting off the ground and impairing control.

The nine-disk clutch in the V-Rod runs in engine oil and has a mean friction diameter of 130 millimeters. The aluminum friction disks are equipped with individual adhesive-bonded pads; the driving disks are manufactured from sheet steel.



Clutch on transmission input shaft

The outer and inner clutch cages are aluminum diecastings. Five springs inside the inner cage act on the clutch disks. The clutch is actuated by a hydraulic slave cylinder mounted in the clutch cover.

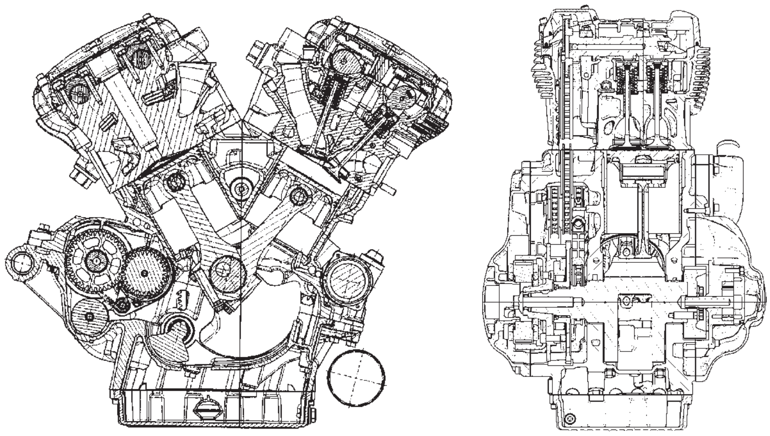
Two spur-toothed gearwheels form the primary gear train from the crankshaft to the transmission input shaft, and another gearwheel compensates for the circumferential backlash of these gearwheels. An integrated jerk damper reduces the torque peaks that can result from uneven rotation, popping the clutch, gear clashing or misuse. Clutch disks are subjected to extreme thermal loads under heavy acceleration, and this requires a specially designed lubrication system. Chambers in the clutch hub supply the correct amount of oil to the nine friction disks in line with their thermal load.

The appropriate oil quantities were determined based on extreme acceleration tests and measurements of the drag torque.

Resonance in the drivetrain can place a high load on components – from the crankshaft to the rear wheel. It was therefore necessary to fine-tune the oscillation properties. Vibrations are caused by uneven rotation of the engine and by the very stiff toothed-belt output drive to the rear wheel. Although the toothed belt used is a low-maintenance type, it is twice as stiff as a chain drive and thus produces very high load peaks in the drivetrain. It was possible to reduce the loads to component-friendly levels by installing a drive damper in the rear wheel, a test-optimized crank-mechanism balancer and an effective jerk damper in the clutch. The V-Rod's drivetrain also demonstrates an excellent load-change response on the road.

Transmission

The transmission is a five-speed constant-mesh countershaft type with "classic" two-shaft layout and sequential shifting. All shifting components are housed in the lower section of the crankcase; the transmission shafts are located in the parting plane of the two crankcase halves. Spacing or adjustment of the transmission shafts or shifting components with respect to the respective crankcase is not necessary. The transmission has been designed for an input torque of 200 Newton-meters or 148 foot-pounds.



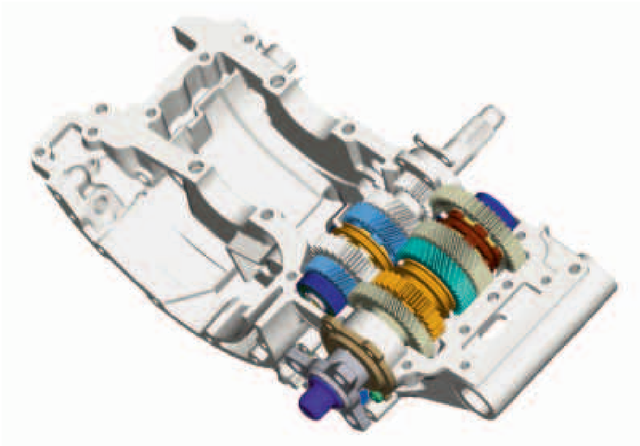
Longitudinal and transverse sectional views of the drive

Gearshift mechanism with gear-selector drum of high-strength aluminum

The gearset comprises a combination of helical gearwheels for the gears that are of importance for noise tests – namely 2nd, 3rd and 4th gears (4th gear as of 2004/'05 in Japan) – and spur-toothed gearwheels for 1st gear and 5th gear. This made it possible to reduce the pass-by noise level by 2 dB. All shift

The drivetrain is one of the Cruiser's highlights.

gearwheels run on needle bearings. They are coupled with the shaft in the usual way by means of operating sleeves for 1st, 3rd, 4th and 5th gears and by means of lateral dogs on the sliding spur-toothed gearwheel for 5th and 2nd gears. The shafts are supported on fixed bearings and loose bearings that are adequately dimensioned to absorb the thrust forces and radial forces occurring during operation. On the output side, forces exerted by the toothed belt must be absorbed in addition to the gearwheel forces acting in the transmission itself.
A two-row deep-groove ball bearing is therefore used as the fixed bearing here.



Transmission mounted in crankcase

The gear-selector drum with milled shift grooves is supported on a steel axle and consists of a high strength aluminum alloy. It is rotated to the respective shift position by the gearshift mechanism. The gear-selector drum also carries the gear stops and the gear lock-in mechanism. Spring forces and kinematic properties have been adjusted to provide clear feedback to the rider and comfortable operating forces. The 4th/5th-gear selector fork is an aluminum diecasting; the forks for 1st/3rd gear and 2nd gear are steel forgings with a brass antifriction layer on the contact surfaces.

Transmission

The collaboration between Harley-Davidson and Porsche Engineering has produced an exceptional result. The V-Rod completely redefined the power cruiser segment when it entered the market. Its combination of characteristics usually reserved for cruisers and dragsters with the performance of a sport bike is currently unequalled on the market. ■

Porsche Styling – a virtual look into the future

Virtual interior model: Material and color variants can be shown with a click of the mouse.

Digital media have now become indispensable tools in the field of styling as well. All employees involved in a development project at Porsche Engineering are networked – and this network also extends to include different locations. This digital working platform saves time and money in the development phase.

The scene: a darkened room. A group of specialists has gathered in front of a large projection screen to assess the styling of a new vehicle by viewing a virtual model. All details are visible: exterior contours and the interior, engine, axles, surface textures and details.

This vehicle does not yet exist in the real world, however. The perfect reflections and highlights on the seemingly flawless painted surface are an illusion. This virtual model is generated by special software that can realistically render complex data models in real time.

A glimpse through the lightly tinted glass reveals a complete interior covered in marine blue leather. Someone wonders how the passenger compartment would look with a light interior color. The answer is just a mouse click and a fraction of a second away.

This is the quick and easy way to show design alternatives. Just moments later, the tachometer expands to many times its original size, filling the entire screen so that designers can discuss the typography on the instrument dial.

Virtual reality is part and parcel of day-to-day work at Porsche Engineering – including design work, which forms the basis for all further development steps. However, experience at many design studios has shown that a dogmatic approach to using digital media is more of a hindrance than a help in the development process. This is particularly true when studios wish to recoup the high cost of CAS (computer-aided styling) systems as soon as they can. They then tend to use these systems exclusively, irrespective of the task.

3D tractor model: Porsche Styling has also been designing industrial vehicles for more than 20 years.

CAS systems are not suitable for all steps in the design process, though. If they are used anyway, this will give rise to additional development loops that do not necessarily produce the desired result. This is a waste of time and money.

Porsche Engineering therefore combines digital possibilities with all other design techniques to form a sort of "toolbox". The most suitable tool is selected for the task at hand, without losing sight of the overall development and interfaces with other areas. This is the only way to ensure that a reliable product emerges at the end of the development phase. And this product does not necessarily need to be a car: Porsche stylists have had a hand in developing everything from wind turbines to Airbus cockpits.


The initial design sketches are scanned and then edited in color with an electronic stylus.

From sketch to physical model in no time

The first sketches are prepared by hand during the initial design phase. Ideas are put to paper and themes are defined. Digital media are introduced as early as when these sketches are illustrated. A scanner imports the free-flowing line drawings into a graphics program. In the next step, the designer uses an electronic stylus to prepare the color designs, the so-called renderings.

Using the computer model, the designer can rapidly create an initial 3D model to verify proportions and check important styling themes. He can also show additional variants with little effort. These conceptual 3D models are used mainly within the design department; they are not yet detailed enough for presentation purposes. However, these simple data models are useful as templates for renderings. The individual depictions are subsequently refined in an illustration program.

Rendering: 2D vehicle sketch from the computer

Vehicle ergonomics is a specialty of Porsche Styling – even if the vehicle in question rolls on only two wheels.

Design themes selected during this phase can then be modeled in more detail on the computer. The objective here is create a digital model that is as true to life as possible. Its shapes and surfaces should be so realistic that the design can be assessed without distractions.

Another decisive requirement in this phase: the computer model must take all technical boundary conditions into account. Package engineers import so-called interface data to ensure that this requirement is met. These data immediately reveal any component collisions or violations of clearances. Once the digital model has reached a level of refinement at which all recognizable defects have been eliminated, a physical model is milled using the data.

Data transfer by scanner

The virtual model is of crucial importance for an all-digital design and development process. It forms the basis for communication between participating development departments and is therefore updated constantly. In this process, the physical model is used mainly to verify the data.

Even if modifications have to be made on the physical model due to their complexity, the new shapes have to flow back into the digital model as soon as possible. A versatile, high-performance scanner quickly scans the model and returns the new data to the computer. It is one of the most important implements in the styling toolbox.

A scanner of this kind is also used after automotive wind-tunnel tests, for example. Modifications made to the wind-tunnel model can be acquired rapidly by the scanner, and stylists can then incorporate them in the design model without compromising the aerodynamic effectiveness of these changes. ■

High-performance sports car with technology of the future

With the development of the Carrera GT, Porsche has not only unveiled the technological possibilities now available in sports car construction, but the high-performance sports car also gives an insight into Porsche technology that might be deployed in the future. The car will make its debut in March at the Geneva Automobile Salon, where it will be on public display for the first time ever.

The visual appearance and overall build of the Carrera GT at first glance betray that its origin lies in motor racing. Porsche's latest sports car creation has a thoroughbred racing engine. The ten-cylinder engine with dry-sump lubrication is based on the 5.5-liter V10 normally aspirated engine that was developed especially for racing activities. To suit mass production, engineers at the Development Center in Weissach have increased the displacement to 5.7 liters.
The maximum output is 450 kW or 603 bhp (SAE) at 8,000 rpm and the maximum torque is 590 Nm (437 ftlb.). The Carrera GT enters entirely new dimensions in terms of driving performance. It reaches a top speed of 330 kilometers per hour and accelerates from zero to 100 km/h 3.9 seconds. The Carrera GT completes the sprint from zero to 200 km/h in 9.9 seconds. A specially developed six-speed manual transmission ensures optimal transfer of the drive power to the road.

A new construction concept was developed for the first time for road and racing vehicles – both the monocoque and the entire sub-frame are made of carbon-fiber reinforced plastic (CFRP). Its functional and formal unity distinguishes it from all previous creations. Porsche has applied for a patent for this trailblazing principle. Carbon is the only material that, after complex processing, can meet the prerequisites needed to combine top-class driving performance and driving dynamics with minimum weight and maximum rigidity.

With attainable speeds of more than 300 km/h, aerodynamics plays a crucial role. To achieve the highest downforce possible, the Carrera GT has an underbody geometry that can only be found in similar form in thoroughbred racing cars.

The Carrera GT is decelerated by the Porsche Ceramic Composite Brake (PCCB). A global innovation takes care of power transmission: the PCCC (Porsche Ceramic Composite Clutch). The PCCC's high performance, compact dimensions and outstanding durability set it apart.

The Carrera GT and these up-to-the-minute technologies will be presented to the public at the Geneva Automobile Salon. Porsche Engineering will also be at the Porsche stand to provide information about the technology, the materials and the entire range of engineering services.

Carbon played a crucial role in the design of the Carrera GT. The complex processing of this material allows for superior performance combined with minimum weight and maximum rigidity.

Even more power, driving pleasure and safety

Engineers at the Porsche Development Center in Weissach have completely revamped the GT3. In doing so, they gave top priority to achieving the ultimate driving experience, realizing great driving safety and minimizing weight wherever possible.

The engine in the new GT3 has an output of 280 kW or 375 bhp (SAE), 21 bhp more than the engine in the predecessor model, and propels the car to a top speed of 306 km/h or 191 mph. With its specific power output of 77.8 kW or 104.3 bhp per liter, the 3.6-liter horizontally opposed engine is one of the world's most powerful normally aspirated engines in its class. The GT3 finishes the sprint from 0 to 200 km/h (124 mph) in a mere 14.3 seconds.

This extra power was achieved by boosting the engine speed. Depending on the engaged gear, the engine now redlines at over 8,200 rpm, making the engine in the new 911 GT3 400 rpm faster than the unit in its predecessor and greatly enhancing the car's sprinting characteristics. Accelerating from a dead stop, the new GT3 reaches 100 km/h (62 mph) in 4.5 seconds, three tenths of a second faster than its predecessor. It now takes only 9.4 seconds to reach 160 km/h (100 mph) instead of the 10.2 seconds for the earlier model. At least 80 percent of the maximum torque of 385 Nm (285 ftlb.) is already available at engine speeds above 2,000 rpm (previously: 370 Nm or 274 ftlb.). The transmission has been equipped with a transmission-oil cooling system and oil-spray lubrication and several of its key components have been reinforced to cope with this performance enhancement.

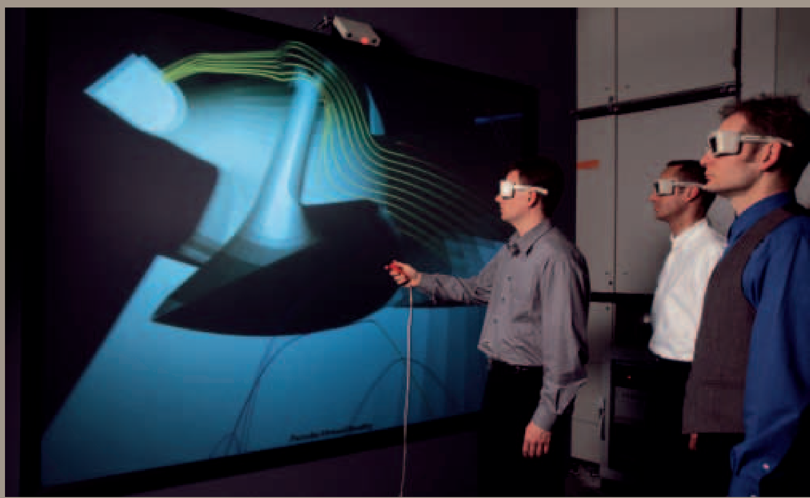
Our engineers have further refined the brake system. The GT3 was equipped with more powerful 6-piston monobloc brake calipers (previously 4 pistons) at the front axle. The front brake disks grew by 20 to 350 millimeters in diameter and feature Porsche-patented cooling ducts. The anti-lock brake system was also modified. The new system (ABS 5.7) is characterized by an even faster and more precise control response. Additional advantages are the lower weight and greater vehicle stability when the ABS goes into action during braking.

The dominant rear wing is the distinguishing visual feature of the new GT3. Offering multiple adjustment possibilities, it plays an important part in ensuring the car's rail-straight tracking at high speeds and generating the increased downforce in high-speed curves. The front apron was also redesigned. These aerodynamic refinements have given the GT3 a drag coefficient of $c_d = 0.30$, a superlative value for a vehicle in this class. The new 911 GT3 will be launched on the European market in March 2003. ■

The dominant rear wing is the distinguishing visual feature of the new GT3.

Virtual reality and collaborative engineering

The Stuttgart region is home to many leading developers in the field of virtual reality (VR), as well as users and providers of this technology. This high concentration of knowledge has now been bundled by a collaboration project at the "ViRCE" (Virtual Reality and Collaborative Engineering) Competence Center.



Digital development: depiction of gas flows in an engine

The objective is to make the latest VR technologies accessible to innovative companies as well as to facilitate rapid exchange of technical expertise between the partners involved.

Speed is one of the most important competitive edges in the manufacturing industry. Rapid prototyping, 3D CAD, networked designs and numeric simulation methods have already greatly accelerated development processes. With the aid of virtual reality, results from a computer-aided development process can be presented in a realistic and interactive manner. This eliminates expensive prototypes and thus saves time – one reason being that mistakes can be recognized and fixed at an earlier stage. The ViRCE collaboration project now provides a communication platform and high-quality VR systems and technologies for companies, universities and research institutes in the Stuttgart region, paving the way for the latest research findings to enter practical applications. Knowledge is deepened through an intensive exchange of information between the research community, suppliers and users. Technology in the field of virtual reality and collaborative engineering can thus be put to use faster and on a more practically oriented basis.

Companies can use VR systems, hold presentations or have data prepared for VR demos (CAD/CAE/VRML data) at a demonstration and service center (Demo- und Dienstleistungs-Center DDC). This also gives small and medium-sized companies the chance to use up-to-the-minute virtual-reality technologies and to arrive quickly at an ideal solution.

Based in Fellbach, the Competence Center was established at the initiative of the economic development program for the Stuttgart region and is run as an incorporated society for economic purposes. Companies from the automotive and supplier industries, information-technology companies, universities and research institutes are involved in this collaboration project.

Porsche is represented on the management board of the newly founded Competence Center. Porsche Engineering therefore also has direct access to the resources of the ViRCE and can make years of experience it has gained in its development work available to the Competence Center.

Done with the wind

In the period from 1940 to 1951, Porsche broke new technological ground in constructing wind turbines in three power classes for the Berlin-based Wind Power Research Institute.

In the period from 1940 to 1951, Porsche broke new technological ground in constructing wind turbines in three power classes for the Berlin-based Wind Power Research Institute.

The wind turbine shown (Type 135) is the first version and was capable of generating 130 watts of power. Type 136 could already produce 736 watts and featured a four-blade rotor. The blades were adjustable, allowing control of the power and speed. This also protected the turbine against gale-force winds. The most powerful version, Type 137, had an output of 10,000 watts. It had three four-meter-long blades, which were 65 centimeters wide at the middle and weighed 70 kilograms each. The mechanical and electrical generating equipment was housed in a lightweight, swiveling pod with directional vanes, which was in turn mounted atop a 17-meter steel tower.

By way of comparison: the wind turbine that Porsche Engineering styled for DeWind in 2000 produces two megawatts of power. ■

Ferdinand Porsche (second from the right) and his son, Ferry (right), testing the first turbine in front of the design office in Zuffenhausen in 1940.

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Publisher
Porsche Engineering
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Address
Porsche Engineering
Group GmbH
Porschestraße
D-71287 Weissach

Tel. +49 (7 11) 9 11-1 88 88
Fax +49 (7 11) 9 11-1 89 99

Email: peg@porsche.de
Internet:
www.porsche-engineering.com

Editor-in-Chief
Sabine Schröder

Editor
Jens Walther

Production
Werking
Werbekonzeption & Realisation,
Stuttgart

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