Inside job

Will advances in simulation packages, engine dynos, and data acquisition soon enable engineers to develop new powertrains purely in the lab environment?

WORDS BY JOHN CHALLEN

The need to cut costs, time, and the manpower dedicated to an engine test program is an ever-present prerequisite. Powertrain engineers have been able to take advantage of sophisticated simulation and modeling tools, but in recent years there have been stumbling blocks that threaten to slow things down and increase costs, exacerbated by the need to bring to market alternative powertrains. Not dealing with solely tried-and-tested components, such as injector systems and intake ports, simply means more work, new parts under the skin of the vehicle, and a new set of problems.

These constant challenges are things that, as head of engine and powertrain development at Porsche AG, Dr Hans-Jakob Neusser has had to deal with in recent times.

"Customer demands on a vehicle have increased," he states. "Years ago, the main issues were power, torque, and fuel consumption, but now we have to consider the engine's sound, suitability for daily use, and durability. The more complex a system is, the more work you need to do on virtual prototyping and component test bench work. With EVs the workload will not be doubled, but it does require a different kind of work, within the system interaction."

Porsche takes every powertrain in isolation, but adopts the same structure for development, explains Neusser.

"First is design work, and simultaneously we do virtual analysis of everything from the components up to total vehicles. The aerodynamics are also done by simulation of virtual prototypes."

RIGHT: Ensuring a 911's engine makes all the right noises, while staying within the law

"For alternative powertrain work, I would say there is a 50:50 split between lab and total vehicle work, but I see it moving further toward the test rig"

Dr Hans-Jakob Neusser, Porsche AG

Bench testing follows after the first parts are processed, using rapid prototyping. Here Neusser's team checks for durability and operational behavior in the lab. Only when they have confirmation of these aspects does the project move to optimization of the system and integration into prototype and pre-production vehicles.

"As the dynamic driving behavior of a hybrid powertrain is different to that of a conventional engine, many elements of the test program have to be altered," says Neusser.

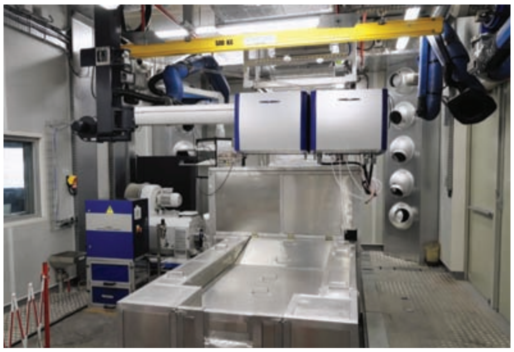
"The quality of the conventional adjustment and calibration work can be influenced by the electrical parts. This work can be done by virtual prototyping, transferring it to bench testing, and then finally validating it in the final vehicle. For alternative powertrain work, I would say there is a 50:50 split between lab and total vehicle work, but I see it moving further toward the test rig."

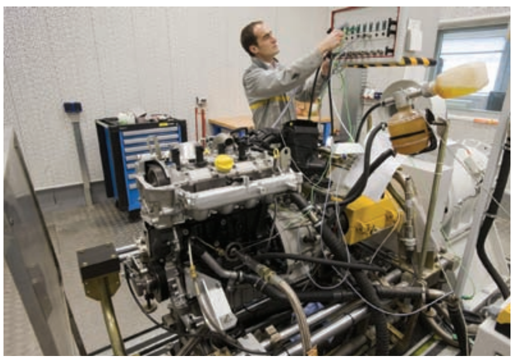
For comparison with a conventional powertrain test program, Neusser explains that for V8s, the mechanical test program was done 80% in the lab, with thermodynamic and application work closer to a 50:50 split.

The rise of computer power is also something that Mazda's program manager in the powertrain development division, Yasuhiro Harada, is keen to discuss.

"When developing an all-new engine, we use computer simulation exhaustively from the conceptual phase in order to design the basic structure"

Yasuhiro Harada, Mazda





Harada does not think this is the smartest choice, "It is trying to make technological advances by simply replicating actual tests using computer models. Computer models have a more important role. We use them to try out new ideas, create new designs, and also to optimize existing ones."

Renault has made a recent investment in a powertrain facility in Lardy, just outside Paris, as the French manufacturer concentrates more on engine testing in the lab. The new site features state-of-the-art engine and chassis dynos, as well as altitude and climatic chambers, and sophisticated HIL capabilities.

Pierrick Cornet, manager for the powertrain tuning department, says, "The aim for us is to stay as long as possible in the lab, because it means reduced planning and R&D costs and we can offer more proposals for our customers, in terms of reducing emissions.

"We try every day to move from tracks to chassis dyno, and from testing to simulation," he continues. "We use offline engine tuning, with one car on which we can evaluate standard conditions such as speed and altitude; and all the tests are made on chassis dyno. We then have some specific models for the database, which should be on the real-life drivers. This is where we can check to see if our tuning is OK."

One of the major capabilities at Lardy is the ability to simulate the load with the transmission, vehicle, and road data, then feed the test bench with this information.

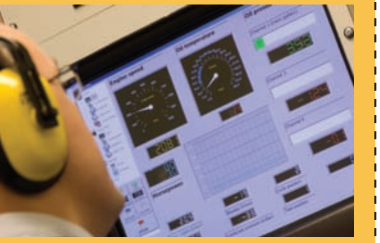
Race-ready simulation

It seems the lab development of a race-car engine poses as many problems as one for the road. However, in developing the V12 for the Superleague race series, MCT relied heavily on computer power.

"Things we would normally do, such as optimizing the intake systems before we started pouring metal on the flow rigs, we just didn't do," says Dave Bedborough, MCT's technical director. And we didn't run a single-cylinder engine to see if that would produce what we thought it would – all the work was based on electronic data."

Bedborough says the brief MCT was given for the engine was just that – brief.

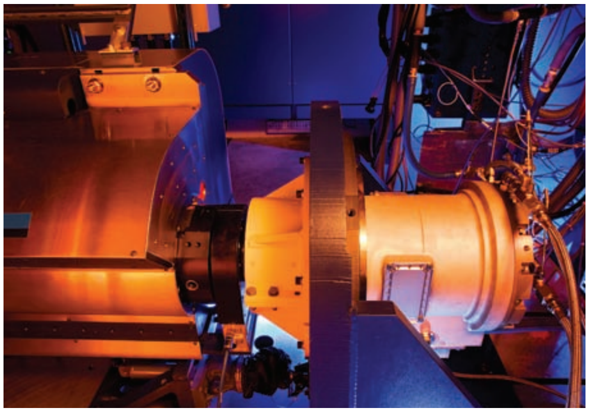
"The engine had to have 750bhp, and needed to be no longer than 700mm," he reveals. "They gave us the chassis it had to fit in, which compromised the auxiliary layouts on the side of the engine, and I set about generating numbers for power output, bore, and stroke, which we put through 1D code."



When it was all put together in the design package – UniGraphics was the main weapon of choice – Bedborough says he was happy with the outcome.

"We tried to have one person in command and other people working in specific areas, responsible for bottom end, heads, and intake system, and CAD-wise it came together very nicely.

"I wanted to make the V12 a good-looking engine, and 3D CAD allows you to do that," he adds. "We ran Abaqus FEA and stressed all the major components to ensure we didn't get any failure modes."



"Once correlated to good customer usage, rig testing can, to a large extent, be used for design verification at powertrain system and engine subsystem level"

Daniel Kok, Ford, UK

LEFT A non-fueled hybrid spin cell at GM's in-house powertrain facilities

"This setup enables us to simulate the drive cycles for homologation as well as simulating weather conditions from -10°C to +30°C," explains Cornet. "From testing to simulation, specifically for engine management software, we use HIL validation. The software in engine ECUs works on real-time conditions with simulation and is connected to models and real parts. From the ECU we can then make thousands of simulation changes."

In reality, there doesn't seem to be a straightforward yes or no answer as to whether the future of engine development lies solely in the lab, but most agree that it will be validation work, not development work, that is done outside the lab.

"By 2020, we plan to carry out the majority of our engine development through computer simulation models," confirms Mazda's Harada. "We will still use actual vehicles and engines for development, but it will be limited to verification and final tuning."

Renault's Cornet, meanwhile, is a little more certain: "I think it will be possible but it will depend on whether it is a grandmother engine (first in a new family), or a child (derivative) engine. For a brand new engine, we need to have collaboration between the simulation and reality and then it is easy to simulate."

It is an issue that divides powertrain engineers. Across the water from Cornet is Daniel Kok, a Ford powertrain engineer based at Dunton Technical Centre in the UK, which was runner-up in the Engine Test Facility of the Year category of the *Automotive Testing Technology International* Awards 2010. Kok has a different stance.

"Once correlated to good customer usage, rig testing can, to a large extent, be used for design verification at powertrain system and engine subsystem level," he says, adding that formal verification tools can help with robust sign-off of powertrain control software.

"But with new feature contents, for example in vehicles with stop/start or hybrid-electric powertrains, we see a steady increase in the use complexity to which a vehicle is subjected. For this reason, the final product validation will continue to rely on testing the vehicle and its powertrain in a representative real-world environment."