A lifetime of **vehicle service loads** simulated within a few weeks

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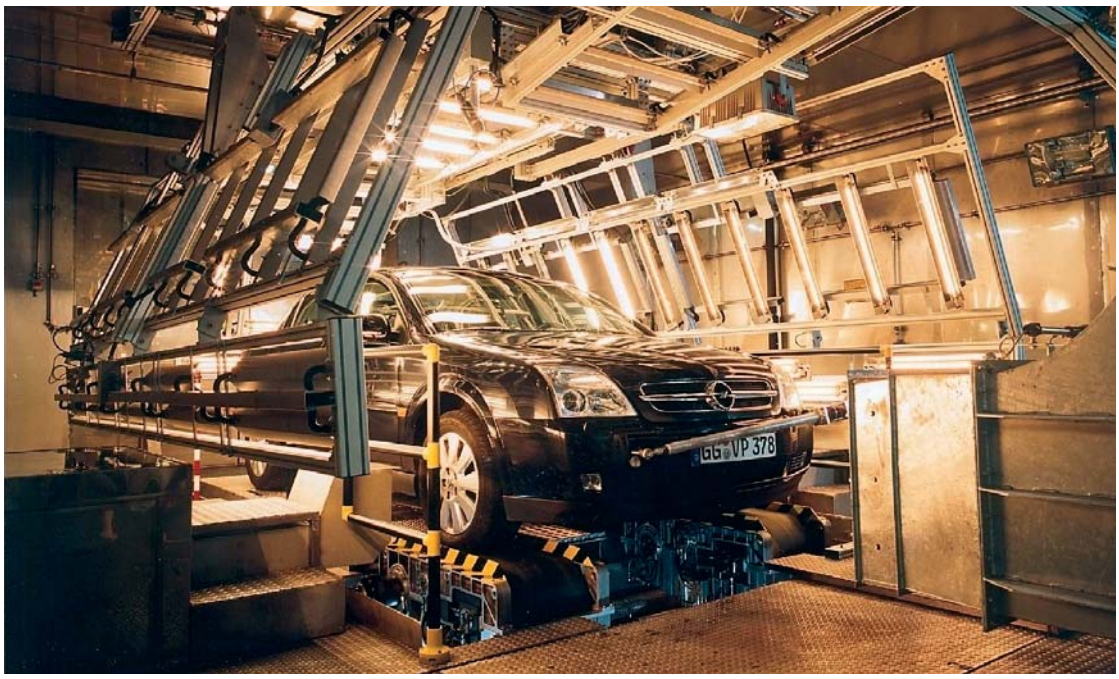
In close co-operation with IST of Darmstadt, Germany, German automobile manufacturer Adam Opel AG have installed a 'deterioration' test system for complete vehicles, enabling extreme mechanical and environmental loads to be simulated in the laboratory within a minimum of time but with highest accuracy. A novel feature of the test system is that the driven wheels of the vehicle run on flat roadway units mounted on Hydropuls actuators. With the help of these flat roadway units, the tests can reproduce even more accurately the conditions experienced by the car under actual road-driving conditions, eliminating the need to separately simulate the frequency response functions of the tyres and the loads acting during acceleration, gear shifting and braking.

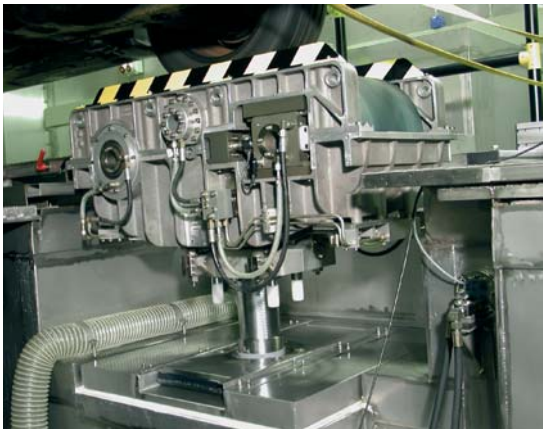
To reduce development times, and at the same time eliminate virtually all potential faults before the vehicle reaches the customer, are two conflicting requirements, which can only be met by performing fast, condensed laboratory tests on a complete vehicle, which duplicate actual service conditions as accurately as possible. The new 'deterioration' test rig taken into service in spring 2002 at Opel's International Technical Development Center (ITEZ) in Rüsselsheim/Germany enables a complete car, including the power train, to be exposed to loads equivalent to those acting on the vehicle under road-driving conditions. All loading data required for the introduction of mechanical and thermal loads to the test object are obtained from road measurements, and are then applied to the vehicle on the test rig in real time or in accelerated form.

Closely interwoven functions

'Fuel reserve below minimum' – this message will trigger multiple inter-related reactions: The hydraulic actuators underneath the contact patches of all four wheels, which had until this point applied highly dynamic vertical movements at various amplitudes and frequencies into the complete vehicle, move to their rest position. The system's automatic pilot operates the accelerator pedal to decelerate the vehicle, changes gear, waits for the wheels to come to a standstill and finally turns the ignition key to



New deterioration test rig at Opel's International Technical Development Center (ITEZ) in Rüsselsheim, Germany.



IST took responsibility for the co-ordination of all functions and the provision of the master control system, including visualisation of the testing sequence.

Top left: Piston with installed flat-roadway unit.

Above: Autopilot in use.

Below left: View of the control centre.

the OFF position. At the same time, the oncoming air flow is reduced in accordance with the vehicle velocity, which is derived from the wheel speed, until the wind has stopped altogether, and the temperature in the testing chamber rises to a comparatively moderate minus 20°C, even if Arctic temperatures had prevailed beforehand. In the meantime, the exhaust gas extraction system has been switched off and the fuel nozzle for the right fuel type unlocked in the fuel supply system, ready for an Opel engineer to start refuelling the vehicle. The 'mastermind' controlling all these functions is a host computer supplied by IST, which provides all test control functions and triggers all other computers forming part of the overall test system.

Numerous specialities all under one roof

This brief and by no means complete description merely provides a rough outline of the complexity of the system and of the numerous challenges, which Opel and IST faced, and which had to be met in order to reduce danger for man and machine during the test to an absolute minimum.

The list of major assemblies is as comprehensive as the features of the system, and includes:

- Test rig foundation, vibration-isolated from the building by means of spring damper elements;
- Patented flat roadway unit;
- Speed-controlled electric motors, laterally coupled to the flat roadway units by means of universal-joint shafts, including their controllers;
- Autopilot for automatically controlling the driving functions;
- Electrical positioning units for the flat roadway units at the front and the wheel pans at the rear, providing for adjustment of the track width over a range of 1300mm to 1700mm and of the wheel base over a range of 1800mm to 3200mm;
- Environmental chamber including infrared radiation units and control system, enabling the simulation of temperatures ranging from -40°C to +80°C and relative humidities ranging from 10 per cent to 90 per cent at temperatures from +10°C to +55°C;
- Wind blower for generating wind speeds up to 160km/h;
- Fuelling box arranged within the environmental chamber, equipped with emission sensors, extraction system and CO2 fire extinguisher, and
- Vertically arranged Hydropuls® linear actuators, thermally insulated from the environmental chamber to introduce loads into the vehicle.

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Through the interaction of all relevant parameters on this new deterioration test rig at Opel, a vehicle can be exposed within a period of three to four weeks in round-

Static force rating:	±160 kN
Dynamic force rating:	±128 kN
Nominal stroke:	±150 mm
Test frequency:	max. 50 Hz
Max. piston speed:	3 m/s
Perm. loading of anti twist lock:	500 Nm
Max. acceleration, VA	350 m/s_
Max. acceleration, HA:	700 m/s_

Table 1: Technical specifications of the IST Hydropuls® linear actuators generating the vertical movement of the flat roadway units.

Weight	275 kg
Max. velocity	200 km/h
Short-term	250 km/h
Power capacity	100 kW
Max. wheel load	10 kN
Permissible side load	5 kN
Max. braking force at the belt	10 kN
Max. braking torque	ca 2.000 Nm
Running width	376 mm
Usable length	600 mm

Table 2: Technical specifications of the flat roadway units.

the-clock operation to loads equivalent to a travelling distance of around 160,000km.

A novel feature: flat roadway units

One of the most important objectives in the design of the new Opel test rig was the inclusion of the complete power train and the extension of testing capabilities to include operation with running engine. The driven wheels were to be able to roll under the same conditions as on the road, with the ability to move vertically. With due consideration to these requirements, the only feasible solution was the use of so-called flat roadway units. To be able to simulate the vertical excitation of the wheel, the roadway units had to be mounted on Hydropuls actuators, which meant that the mass of the units had to be reduced to a minimum, to keep the moving masses as low as possible.

As there was no flat roadway unit with the required features available on the market at that time, an extremely light weight and low-cost design was developed by an engineering partner under the leadership of Opel and completed within a period of 18 months. Due to its relatively simple design, low deadweight and wide range of operating temperatures, the new patented flat roadway unit is ideally suited for use on vehicle test systems.

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The running surface as such is designed in the form of a multi-groove V-belt. The belt is made from elastomer and reinforced with textile, and is wound round two profiled return pulleys arranged at a relatively short distance relative to each other. A third, smaller pulley supports the belt underneath the vehicle tyre. At 275kg, the complete unit weighs no more than one-tenth of the weight of the hitherto known designs and is therefore the first to allow the efficient simulation of vertical loads at the relevant frequencies up to approximately 50Hz.

The flat roadway unit is connected through a shaft with constant-velocity joint to an electric motor, which can serve as dynamometer or as braking unit, depending on the required driving manoeuvre. An additional advantage provided by the compact design lies in that it has enabled a walk-in pit to be built underneath the vehicle. This means that the vehicle can easily be inspected from below.

Engineering from IST as integrating feature

The 'mastermind' controlling all subsystems involved is the process control system supplied by IST. In general terms, the host computer connected to IST's Labtronic 8800 measurement and control system transmits all control signals required for the operation of the deterioration test rig – signals for track and wheel-base adjustment, for the drive motors, signals controlling the movements of the actuators underneath the wheel pans at the rear and the flat roadway units at the front, the wind speed, and, by way of the autopilot, even the position of the accelerator and the braking force on the brake pedal. Only the IR lighting system, humidity and temperature are controlled by the control system of the environmental chamber, with the IST computer synchronising the sequences of operation with the overall system.

Universal hard and software

With the new deterioration test rig, Opel can not only bring summer and winter into the test laboratory, but can also reproduce a variety of test tracks, either as they actually occur, or in condensed form, reduced to the damage-relevant loads. For this purpose, velocities, moments and accelerations are acquired in the field at various reference points on the vehicle, stored and then processed with the help of the RS TWR (Time Waveform Replication) software suite. This simulation software supplied by IST provides the data required for highly accurate reproduction of field loads on the test rig and, thereby, for accelerated ageing. For this purpose, the IST system first

determines the frequency response function of the test object and then calculates the required drive signal on the basis of the desired response signal, whereby the system response to the excitation signal is optimised in an iterative loop.

This process is followed by the actual test in the testing chamber, which is set up and monitored by the test engineer with the help of the RS LabSite test software and the RS Console user interface. The relevant information is displayed on three screens – one for the host computer, one for the visualisation computer (both supplied by IST) and one for the computer controlling the environmental chamber and the infrared radiation units.

To complete the test, damage analysis is performed with the help of the TecWare software suite provided by LMS International of Leuven/Belgium, IST's alliance partner within the framework of the 'Durability Alliance'.

The test equipment is being used successfully for a variety of different tasks. The test facility is highly in demand, particularly for development projects involving extreme climatic conditions, considering that it provides the opportunity to perform tests under winter conditions in summer, or under summer conditions in winter, whilst at the same time significantly reducing the logistics involved and the time required to perform these tests. The area of application of the tool has been steadily expanded. Meanwhile even various development projects relating to fuel-cell vehicles are being conducted on the test rig.

Specialist for road simulation in the laboratory

All over the world, IST offers comprehensive know-how in the areas of service load simulation and components testing on servo hydraulic test systems. Its product range extends from simple, single-axial components test systems to complex test systems for the simulation of virtually all loads acting on a vehicle or component. The modular concept of the test systems enables individual components to be tailored exactly to the user's requirements. The test systems enable all loads experienced by a vehicle throughout its lifetime to be simulated in the laboratory within a short period of time. ■

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