Tread carefully

Advances in tyre tread measurement appear to have gone trackless. This multifunctional system not only measures tyre tread depth but also the tyre type (winter or summer tyre) as well, during traffic flow

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Society has an eye on driver behaviour with regard to excessive or inadequate speed, or driving under the influence of alcohol or drugs. Nobody seriously questions that these are major reasons for road accidents, and most of the controls used by the police or other authorities are directed at such misconduct.

Although alcohol controls are mainly triggered by suspicious behaviour, rather than by objective criteria, speed controls are quite automated and deliver indisputable evidence. But however efficient such controls become, they ignore one very important matter, without which road traffic would not exist: technology, or rather its inverse relative, namely the technical defects or insufficiencies of vehicles that also contribute to the accident toll.

Tyres are the trouble

So how big a factor are mechanical defects in the causes of accidents? Most of us might think of a huge truck out of control, speeding downhill with smoking brakes, tipping over at the next bend, or crashing into the end of a queue of vehicles. But who honestly would think of tyres?

Yes, tyres are the main technical cause of road accidents in Europe. Based on figures recorded in Germany in 2002[1],[2], accidents caused by 'general tyre causes' amount to 60,000 a year, 10,000 of which are due to undercutting the legal tread depth limit of 1.6mm. This results in economical damage of Euro 200 million[2], not to mention the harm and misery of an irrecoverable damage of health, or the loss of a loved one.

In light of the above, the question should be raised as to why more than one in 12 drivers[3] accepts at least one bald tyre on his vehicle. There are several reasons for this. In many cases, the motivation is simply to save money – the tyre will 'carry on until the next periodical inspection'. In other cases, it is just the disregard of a high-cost but low-interest commodity. Many people are interested in vehicle performance and fuel consumption, but tyres are low on the list of priorities, while some people are just surprised that their recently purchased set of tyres has worn out so quickly. Last but not least, the neglect seems to be the result of 'the curse of the good deed'. The warning lights and systems on modern cars exclude drivers from almost all technical responsibilities, so gone are the days when the responsible driver walked around his vehicle before starting up, controlled the tyre air-pressure at the filling station, and checked the oil and brake fluid levels for themselves.

So what is the best way to get out of this situation? Better driver education is always recommended, and more sensitization of motorists concerning tyre awareness could be helpful. But how can the unteachable, the insensitive, and the lazy be reached? Probably by the same means that put them into this corner: technology.

Intelligent roads

Imagine the scene 12 years from now. Intelligent roads communicate with smart vehicles to guide their drivers in a safe and fast way to their destinations. 'Vision Zero' is the accepted common spirit of all transportation and traffic policies. The accident toll is at such a low level that every single accident is published in the daily news.

Relevant vehicle-related technical conditions, also of perishable parts, are monitored continuously and periodical checks reveal status data, which allows the undertaking of component lifetime predictions. An indispensable part of this concert is a network of automated

tyre-monitoring systems. When a car enters a workshop, the tyre-tread depth is scanned automatically and the data registered in the electronic vehicle log book. Before accessing mountain passes, for instance, a scanner checks the appropriateness of vehicle tyre equipment and then grants or denies access. Industries that handle and transport hazardous goods scan truck tyres before loading them. Municipalities operate tyre scanners in sensitive areas to inform the driver about their tyre status, similar to the non-enforcement active speed signs, mostly found in residential areas. Those who still don't care are reached by the authorities, who are also equipped with mobile tyre scanners.

To help make this vision become a reality, ProContour, a small company in southern Germany, is developing a tyre-tread scanner. The ProContour H3-D prototype scans tyres of vehicles in real traffic conditions at speeds of up to 120km/h – touchless and without interference with traffic flow.

The team at ProContour is encouraged by the political atmosphere and the political will to dramatically reduce the number of people killed in road traffic accidents. Numerous safety programmes and philosophies try to give governments and NGOs orientation and a statutory framework. The two most popular programmes are the Safety Charter of the European Union (EU25000), and Vision Zero. The former appears more factual, while the latter expresses the heartfelt desire not to tolerate the sacrifice of one single life by traffic accidents.

Depth measurement

So how does the tyre-tread depth measuring system work? The measuring principle is advanced laser triangulation. A digital high-speed camera looks under a defined angle on the laser line-illuminated tyre surface (Figure 1) and records 3D profiles (the image of the laser line on the tyre surface as a digital picture file). High speed in this context means the camera can capture up to 35,000 images a second. The related image-processing software combines the captured 3D profiles with a 3D map of the tyre surface. As each pixel of the image represents a known position in global coordinates, a special software just has to compare the height information between the upper and lower edges of the main grooves.

However, what sounds so easy is actually a tough challenge for the programmers. Because ProContour H3-D works absolutely independently from external signals, the tread depth information has to be generated exclusively out of the image of several thousand different tread shapes. To teach the software how and where to look, several hundreds of thousands of images have to be captured and analysed. Only by excessive testing and evaluating in distinct steps will the software reach ready-for-market status.

The system is generally placed underneath the road surface. A civil provision inside the road structure accommodates the exchangeable measuring heads, which 'look' upward through a 30mm gap to the passing tyres (main picture). Those measuring heads each have an effective measuring

The H3-D has exchangeable measuring heads, which 'look' upward through a 30mm gap

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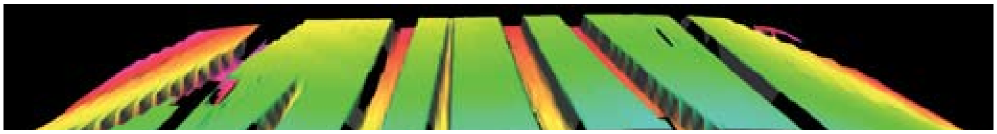
Tyres in the wet

» On rain-wet roads, vehicle tyre tread should draw off the water between the tyre and the lane, so that the contact between the car tyre and the road surface remains and aquaplaning could at least partly be avoided. Despite the fact that the minimum tyre tread depth all over Europe is 1.6mm, experts are of the opinion that conscious vehicle drivers should change their summer car tyres even at 2mm tread depth. For wide vehicle tyres this limit should be 3mm. Winter vehicle tyres, on the other hand, lose their adhesive force on snow-covered road, even with 4mm tread depth. To cross-check and estimate all these security-relevant factors, the image sensor units of the ProContour H3-D system scan the rotating 3D tyre surfaces in time intervals of milliseconds, even at speeds over 120km/h. Measurement results are communicated permanently with the decentralized evaluating software and hardware system. Based on a negative evaluation result, a decision on whether to take a photo and keep a record of the vehicle and vehicle holder is finally taken.



ABOVE: The system scans the full width of the tire
RIGHT: Figure 1: a camera looks under a defined angle on the laser line-illuminated tyre surface

width of 300-500mm. Their modular design allows them to be combined to increase the measuring width. In another design, standardized manholes can be used. A cable leading to the side of the road transfers the image data to a computer for further real-time processing. Real-time capability is a must, as it is all about measuring under real road traffic conditions with speeds up to 120km/h.

Is a fast camera really enough to take sharp pictures of rotating bodies at high speed, or is there another aspect? The physical attributes of the system are a rolling circular body, just like a car wheel, which follows the condition that the area of the circumference which touches the ground has the same speed as the ground, namely zero; otherwise the wheel would slide over the ground. This circumferential area with ground contact is idealised with just a 1D line. In reality, an air-filled rubber tyre forms a 'footprint' under load, which corresponds more or less to the area of a postcard.

If the wheel rolls at 120km/h, a defined point of this footprint will 'rest' for approximately 2.5ms on the road surface. This is the moment in which ProContour H3-D captures multiple images to recombine them in a measuring image. In other words, the system captures an immobile object. The scanned length of the circumferential tyre segment is approximately 20mm, and the scanned width is the full width of the tyre.

Time to market?

The first operative systems have been available for pilot projects since the latter part of 2008. Certification procedures have already begun in several countries and will lead to the first certified system arriving in the middle of 2009. ProContour's project plan provides a product family covering drive-over tread-measuring systems for workshops, forwarding companies, certification organizations, traffic safety initiatives, municipalities, road authorities (private and governmental), and police and other authorities.

In addition to tread depth, the tyre images have the potential that in a further development step, the system will be able to distinguish between summer and winter tyres. Who doesn't recall the fruitless political decision process about winter tyre regulations? Is this indifference caused by a lack of verification tools? «

References
[1] *TÜV Automotive, Survey on Motor Vehicle Tyres & Related Aspects, 2003*
[2] *Statistisches Bundesamt Deutschland, www.destatis.de*
[3] *Results of voluntary tyre checks without legal consequences, executed by TÜV and DEKRA in 2003 and 2004*

Author Q&A

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What other uses could your technology have – weigh in motion, enforcement, etc?
Other than just tread depth, there is the possibility to distinguish snow from summer tyres. An additional piece of software will be developed, maybe by the middle to end of 2009.

What more could authorities do to enforce tyre tread depths?
Until now, there are only manual gauges or stationary stands to conduct such a job. As far as we are aware, there is no other possibility to check tread depth in live traffic, other than using ProContour H3-D.

Do you think we will ever see zero deaths on the road?
I think more important than what we 'think' is the desire to follow a vision to reach even very ambitious goals, such as 'Vision Zero'.

What are your hopes for the technology?
Our hope is that it will spread to many other countries with high traffic density, in order to eradicate at least one accident cause, namely illegally worn out tyres.