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P.60

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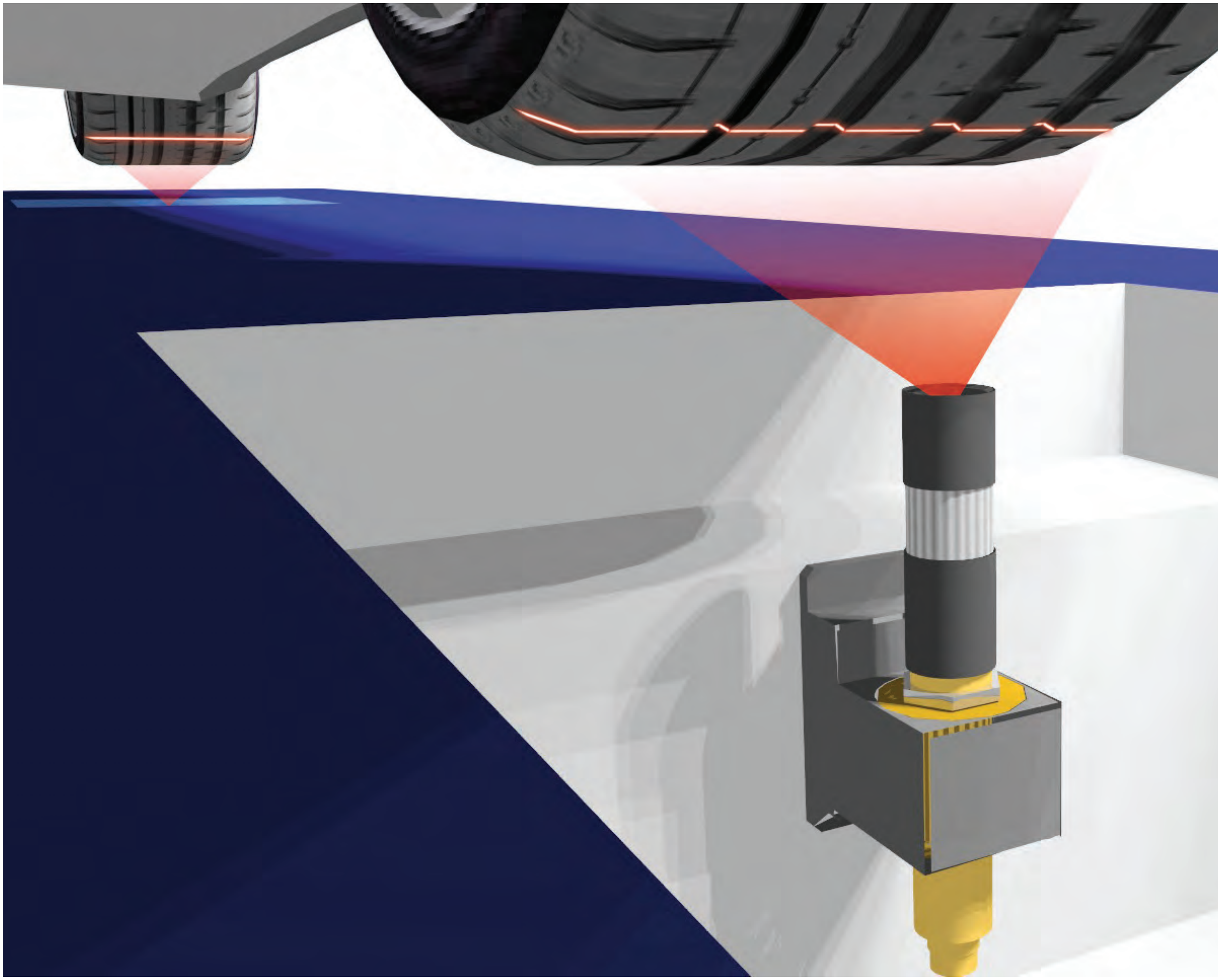


From cameras and QR codes to lasers and sensors, developments in tire machine inspection and vision technologies help to evolve production accuracy. The latest advances in monitoring technology can sharpen the quality control process still further

By **RICHARD GOODING** Images **BLACK DONUTS, SICK, Z-LASER**

For pretty much every conceivable reason, tire production needs to be exact. With more than 100 manufacturing steps, greater control of the processes produces a higher-quality product. Recent technological advances in machine vision and inspection systems have made tire production more precise.

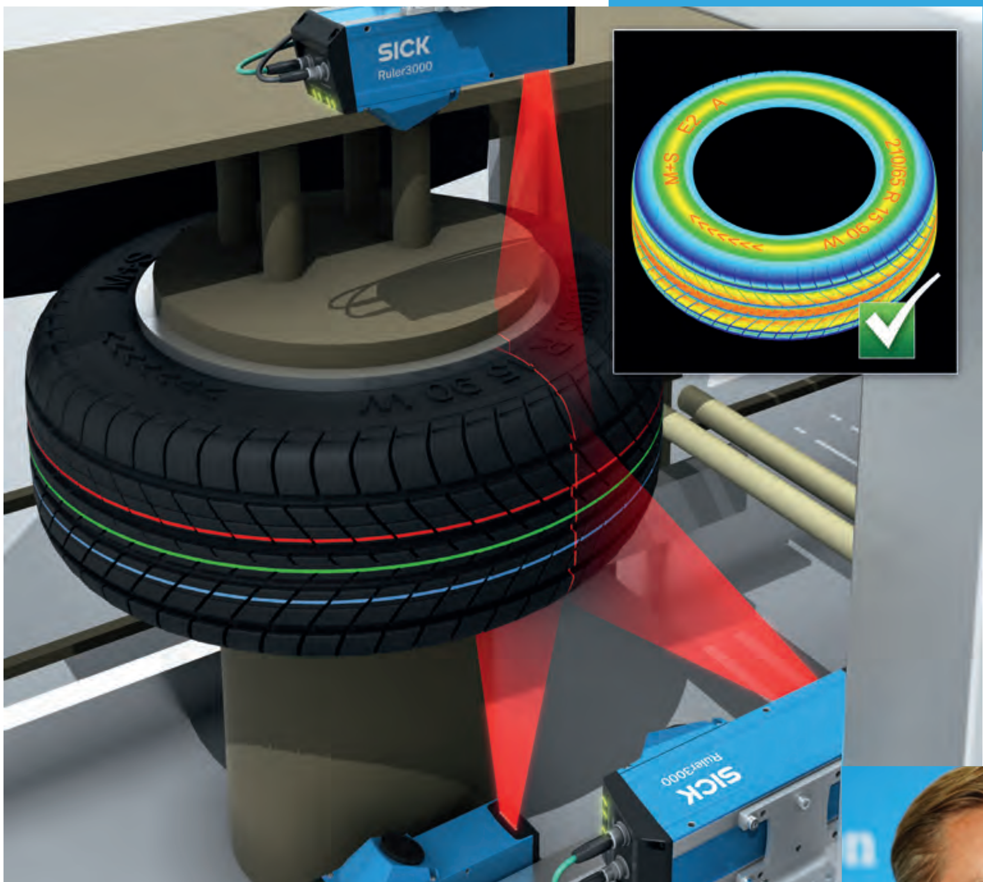
"Improvements in monitoring technology – including cameras and sensors for material dimensions, lengths, centering and splicing – make quality control simpler and more accurate, and the measurement data easily available," says Aki Nurminen, solution manager, smart factory at Black Donuts. "Manufacturers are able to abandon additional, often manual, inspections, such as green tire visual checks, color dot analysis after uniformity and balance machine handlings and mold text inspection after curing."

Pekka Vaittinen, director of automation and solutions at Black Donuts, concurs: "1D/2D scanners are now used for material or tooling verification, with barcode/QR code readings or even RFID in most phases of the manufacturing process. Barcodes and QR codes are cost-effective ways of recognition. Cameras are faster, the number of pixels has increased and the size of hardware has decreased, making it easier to implement. Importantly, the quality of recognition software has constantly improved. Additionally, digital data generated by sensors is stored in databases, centralized by manufacturing execution systems (MES)/manufacturing operations management (MOM) and quality management systems."

"3D vision technologies have taken a big step forward in usability and performance," explains Fredrik Nilsson, head of business unit machine vision at sensor solution specialist Sick. "Cameras have higher light sensitivity, increased dynamic range and vastly improved measurement speeds that allow for increased throughput and more reliable measurements.

"Another big change is the use of deep learning, or artificial intelligence [AI], for industrial machine vision applications. This has become more accessible and possible to execute even in embedded devices. Highly accurate 3D measurements at full production speed, and deep learning, have started to dramatically push quality assurance limits in the tire manufacturing chain."

Accurate measurements, performed at speed, can significantly improve the standard of inspection and quality assurance



ⓘ PERFECTING PRODUCTION

Optimizing tire production through sensor tech

How does sensor technology aid production efficiency and the quality control processes?

"It supports the process fluency, effectiveness and accuracy, and lets operators work 'hands and eyes off' in different process stages," says Black Donuts' Aki Nurminen. "Sensor technology works mostly online, so there is no need to pause a process for measuring or calibrating."

"As the sensor data (information through connectivity) is directly transmitted from different production areas, it is possible to create algorithms related to the causal connection with various process areas," says Black Donuts' Pekka Vaittinen. "This makes troubleshooting easier. Several manufacturing problems will be easier to detect, supporting production efficiency. Many functionalities are already available with existing equipment; you just need to set up your systems, collect the data, analyze it and let the algorithms make life easier."

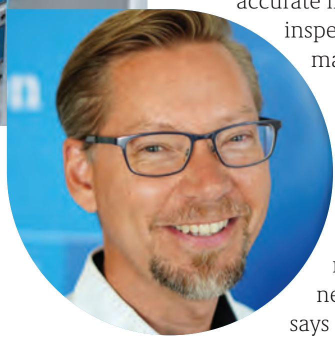
"Neural technologies or AI will help systems to learn new cases on their own, automatically adapting performance to varying material characteristics," explains Sick's Alain Klein. "False-positive and false-negative rates will be dramatically improved. Manufacturing changes can also be analyzed with AI to predict upcoming production line issues. Data generated by sensors could be analyzed to add value in areas other than pure quality control aspects, like machine efficiency and predictive maintenance: basically all possibilities offered by Industry 4.0."

Intelligent functionalities

Automation is among the trends that have gathered pace. "R&D-focused machine suppliers have been testing sensors and intelligent functionalities. Robots are being used in tooling changes, tire handling and internal logistics," says Vaittinen.

"Companies may use a combination of automated and human verification in the future," Nurminen explains. "Human visual inspection still remains efficient and superior in more complex cases, but the latest camera and sensor technologies are more accurate in systematic inspections of texts, markings and logos."

"3D technology associated with AI/deep learning applications will bring automated inspections to a reliability level never seen before," says Alain Klein, strategic



"3D vision technologies have taken a big step forward in usability and performance"

Fredrik Nilsson, head of business unit machine vision, Sick

industry manager at Sick. "The main advantage will be the dramatic reduction of false negatives due to the varying material characteristics that do not affect the quality itself. This will be a strong differentiation for tire manufacturers in terms of productivity."

"As demand for high-quality tires increases, automation is required to produce the necessary quality," explains Ralph Tesson, CEO of Z-Laser's North American OEM division. Global market developments also feed into advances. "As modern transportation in the emerging third world increases, so does the need for higher-quality tires," Tesson adds. "This can only be achieved by automating and measuring the manufacturing processes."

Quality assurance

"The focus on quality issues that could affect the safety and reliability of the finished tire has considerably increased," Klein says. "Tire quality must be checked as soon as possible during the production process to prevent scrap and reduce costs in splice control, DOT code marking and sidewall inspection. Rubber is a dark, low-contrast material, and 3D technology has been used more frequently in these applications."

As Tesson explains, other trends include a switch from red lasers. "Green and blue lasers were cost prohibitive for mass production 10 years ago. However, they are now only nominally more expensive than red and are twice as visible to the human eye for the same optical power. The shorter wavelengths also allow for more precision from the automated camera systems. Adoption of better mounts for the lasers has also increased tremendously."

Moving forward, data generation will play a vital role. "Sensors and technologies that generate data in advanced ways will become more common, such as cloud-based software for statistical process control [SPC] and quality analytics," says Nurminen. "Fewer manual posts measuring length, width or thickness will be needed. These can be automatically measured by cameras and sensors, operators viewing quality measurements through a graphic user interface with multivariate analyses and automatic process corrections. RFID technology may also replace cameras and scanners in production lines."

The ever-evolving range of tire products that fill ever-tighter niches is driving sensor technology evolution.

ⓘ LASER LINES

Sensors must be smart but also extremely tough

The various stages of tire building create potentially harsh environments due to the vibration of machinery and the induction of powerful electric motors as part of the process. Ambient temperature and humidity also vary significantly from one plant to another. Therefore, lasers must be designed and manufactured with these in mind.

"Lasers need to be able to handle a 40*g* level of shock for a duration of 10ms (3ms rise time, 7ms fall time) for +/-50,000 cycles," explains Z-Laser's Ralph Tesson. "Z-Laser also builds lasers that can function in environments from 0-50°C."

Accuracy is also key. "For the manual aspect of tire building, the laser is a much finer line than the process requires," Tesson continues. "A recent trend is to go from red lasers to blue or green – these tend to be more visible against the rubber surface, helping guide operators more precisely. Alignment is a key point. Bimetal mounts with precision microgears help align the laser to submillimeter accuracy, maintaining its position and being resistant to changing temperature or significant vibration.

"For camera-based systems, our laser uses a Powell lens, which creates a homogenous distribution of power along the center 80% of the line (typically this would be a Gaussian distribution). This is key for smart camera algorithms to do subpixel processing and get repeatable submillimeter measurements. For run-out systems, the laser has to be powerful enough to provide sufficient light for cameras to accurately capture the data of a rotating tire at speed ratings of over 130mph [209km/h]. Concentricity measurements are analyzed to determine if the tire can sustain that speed without introducing a dangerous wobble."

> **"Green and blue lasers were cost prohibitive for mass production 10 years ago. However, they are now only nominally more expensive than red"**

Ralph Tesson, CEO, North American OEM division, Z-Laser

"Cameras are faster, the number of pixels has increased and the size of the hardware has decreased, making it easier to implement"

Pekka Vaittinen, director of automation and solutions, Black Donuts

"This is a never-ending issue," Vaittinen says. "Most OEM demands are solvable, but at what cost? Producers are developing sensors, techniques and software that are usable or adaptable in various industries, but in addition to the variety of technologies targeted at the tire industry, it may be fruitful to take a look outside."

"Sensors and solutions are requested that are flexible enough to solve the application and the complexity generated by these ever-tighter niches," says Klein. "We face this request not only for machine vision but for RFID, as well as detection and safety sensors. Application software embedded in our sensors or based in the cloud, associated with common hardware, is a good way to deal with those challenges."

"As manufacturers start to experiment with different, non-traditional tire compounds and chamberless tires for the electric vehicle market, measurements will be related to the different manufacturing stages involved," adds Tesson.

As the variety of tire ranges increases, and as the variability between niche segments becomes vital, inspection and location of tires during and after production will call for increasingly sophisticated sensors and reading technology

Although the pace of development is fast, technological challenges can also be overcome.

"The ever-increasing number of pixels in cameras doesn't require any changes from the lighting side," Tesson says. "They can benefit from more precise structured light only when their processes require submillimeter accuracy. In the semiconductor industry, we produce lines that can be measured by smart cameras and resolve objects to within 0.5µm – this far exceeds tire industry demands today."

"The pace at which new technologies develop is quite astonishing," says Nilsson. "However, the journey to bring a new technology into an industry-proven sensor that provides reliable measurements regardless of the environment conditions is challenging, often needing time. We have to stay updated on trends but need to make a careful choice of what will bring customers the most future value. Sometimes you simply must accept that you are not first on the market as long as what you offer provides the quality and values customers expect."