Quality Assurance for Headlights

Inspection down to the Micrometer

New materials, complex designs and tight tolerances push conventional metrology to its limits in the quality assurance of lighting systems. That is why two Zeiss Metrotom computer tomographs are now in use at ZKW Lighting Systems. They quickly provide comprehensive findings and thus ensure stable production processes and shorter development times.

A modern headlamp consists of up to 300 individual parts that must be assembled and positioned with high precision. © Zeiss/ZKW

Headlights and rear lights fulfill two functions. On the one hand, they are a source of light and signaling for drivers and other road users. On the other hand, they are a defining part of a vehicle's visual appearance. So it is no wonder that a lot of effort has been put into their development in the last few decades. At the same time, the complexity of the components has increased massively. "In the past, a headlight consisted of maybe 100, maximum 150, individual parts; today, it's 300 or more," explains Bernhard Voglauer, Manager Testing System Development at ZKW Lighting Systems. "Furthermore, in the past we only have one lens, today we have objectives with various lenses for the highly precise HD projection of light, which must be positioned exactly."

And new materials for optics, such as silicon, impose new demands on both production and the quality assurance. And finally, the measurement tolerances are getting tighter and tighter all the time. "There were times when we calculated to the one hundredth of a millimeter; today we're dealing with accuracies of thousandths of a millimeter for our HD lenses," says Voglauer. "To achieve the desired lighting results, it's necessary to have the correct distances and the right light axis and to avoid any tilts and turns." Automobile drivers and other road users today already benefit from these things through such features as non-glare high-beam lights and the possibility to illuminate travel signs at night very precisely. These developments mean that ZKW Lighting Systems also needs to take a new path in terms of quality assurance. The reason is that lighting modules have become too complex and new materials like silicon too difficult to capture on a coordinate measurement system or an optical scanner.

Challenge: Inspection of Assembled Parts

The product manager holds up a light module that is used in many headlights and explains how it has been assembled. In the front of the module is the lens with a microstructure on its surface; this distributes the light to achieve homogeneous bright/dark transitions. Behind that are the lens holders and a light source with 84 light diodes. These are controlled individually by a circuit board and lead the clearly-defined light through the silicon light-guide to the lens. This is how targeted fade-out scenarios can be achieved. A metal cooling element and a fan regulate the temperature.

"An important point is this: we have to inspect our components after they've been assembled because otherwise certain error sources cannot even be identified," explains Voglauer. "Our coordinate measurement machines and optical scanners can't do that, of course." During the validation process, ZKW pays special attention to how the light optics have been installed in order to avoid potential damage later on. For example, it once happened that some thermal stress, caused by the light diodes, led to some abrasion on the lens holder and lens. "We would have never been able to identify that if we had only inspected the individual components in a disassembled condition," stresses Voglauer. But such insights are critically important as they enable ZKW Lighting Systems to

Martin Janisch clamps a lighting module into the Zeiss Metrotom 1500 in the measuring laboratory. © Zeiss/ZKW

Bernhard Voglauer (in the back of the figure) and Martin Janisch fine-tuning an X-ray scan with Zeiss Metrotom OS. © Zeiss/ZKW

ensure stable production processes and deliver the premium quality their customers expect.

In-House Non-Destructive Testing

The measurement lab at ZKW Lighting Systems therefore uses the industrial computer tomograph Zeiss Metrotom 1500, alongside various coordinate measurement machines and an automated optical measurement system. A Metrotom 800 is also on the shop floor. For some time now, the company, which develops and manufactures innovative, high-quality headlights, taillights and fog lights at its Wieselburg site in Lower Austria as well as at various other sites around the world, has relied on X-ray technology for the inspection and measurement of assembled modules or entire headlights, previously by an external inspection laboratory. "But we had a lead time of around three to four weeks," explains Voglauer. "This is of course was much too long and didn't fit our idea of efficiency. With our own devices, the final results are available much, much faster, which saves us valuable time in development and allows us to react much faster. That in turn lowers our costs in production."

A high performance of 500 watts and a high resolution thanks to the 3K detector (in the case of the Metrotom 1500) guarantee fast results and a clear view. Even when faced with a complex design with different types of materials, such as copper, aluminum, or different types of plastic with different thicknesses, the computer tomographs can handle it all. "We can do everything very well thanks on the one hand to the different filters and light settings. And on the other hand, a lot can still be done in post-processing too, " explains Martin Janisch, team leader in the measurement laboratory of ZKW Lighting Systems. "Whether correcting artefacts or correcting scattered rays, the software offers numerous possibilities to prepare the result in an optimal way." The high performance of the CT systems also enables ZKW Lighting Systems to scan more than 20 parts at once, in addition to scanning entire headlights.

Interaction of Hardware and Software

In addition to the powerful hardware, the software was another important criterion in deciding for the Metrotom. The analysis of the results is done in GOM Volume Inspect. The employees of ZKW Lighting Systems were already using the GOM Atos ScanBox, an optical measurement device. Zeiss PiWeb is used for recording all results. "This seamless interplay between the hardware and software was a huge factor for us because GOM software is very user-friendly and it offers a visually clear interface with functionalities that are intuitive and easy to find," stresses Janisch. "For us that means a substantially lower training effort. It's always been easy to use and we never have any problems."

In the software itself, ZKW Lighting Systems takes advantage of the possibility to do visual volume inspection in order to mainly inspect the assembly of the components. 3D volume and 2D cross-sections show whether the silicon lightguide is in the right place. The measurement-technical inspection of the components, including the verification of form and position, are also done completely in GOM Volume Inspect. Fly-through videos of the interior of the component and PDF measurement reports are regularly shared with the colleagues from tool development so they can jointly determine the required optimizations. All inspection results from the measurement laboratory are fed into Zeiss PiWeb and then integrated into all systems. And because Zeiss is also "a competent partner that offers great service," the company continues to be set as a partner for ZKW Lighting Systems. ■

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