STEFAN MAIERHOFER

STADIUM OF LIGHT

YOU DON'T HAVE TO GO ALL THE WAY TO BENFICA TO WITNESS WONDERS – THE LATEST LED WORK LAMP DESIGNS ARE ALREADY OUTPERFORMING THEIR XENON RIVALS WHILE PROVIDING SOME ADDITIONAL BENEFITS OF THEIR OWN

Hella has extended its Modular Line with the Oval 90 LED – making it easily interchangeable with the halogen and xenon versions

Press releases about new automotive lighting products are increasingly common. Whereas the current trends may bring back memories of the xenon technology that emerged in the 1990s, the developments in LEDs are dramatically faster and marked by greater creativity and innovation.

For instance, after providing the Audi A8 with the world's first fully fledged LED headlamp with an AFS (adaptive frontlighting system), Hella expanded its cooperation with the manufacturer by developing innovative lighting technology for the new A6. This provides a light distribution that automatically adapts to weather, road and speed conditions by activating the required LEDs appropriately – as well as the dynamic headlamp levelling system – for improved convenience of driving. During accelerating or braking, the modules are raised or lowered to adapt the beam of light to the tilt of the car.

Following first applications in high-priced vehicles for exclusive customers, LED technology is now experiencing a sustained triumphal march through all lighting sectors – including rugged off-highway vehicles such as agricultural and construction machinery.

One of Hella's design prototypes – an LED dipped-beam, daytime running light and work lamp – shows that, technically speaking, an all-LED headlamp system for these types of vehicles and their tough mechanical requirements is already a viable option. With the use of modular components and pre-series developments, the creation of tailored solutions has also become affordable. It is just a question of time until marketable series solutions will be available.

The battle lines are drawn

Work lamps mark a big leap forward in the technology race. LEDs are now well ahead of xenon capsules in terms of luminous power. Whereas the first work lamps with white LEDs could not even compete with conventional halogen headlamps, the latest LED designs already outperform xenon lamps – and provide several additional benefits.

Xenon work lamps are often praised for their luminous power of 3,200 lumen from just 35W consumed. However, this information relates only to the xenon tube and not to the entire work lamp. Components such as the control circuitry consume further energy and some light is lost in the reflector and lens system.

In fact, a xenon work lamp with soundly manufactured lighting functions consumes about 42W of power to output about 2,700 lumen of light. However, some xenon work lamps on the market produce an output of only 2,200 lumen. So, when it comes to making perfect use of the light source in the work lamp, the quality of photometric development is an essential factor.

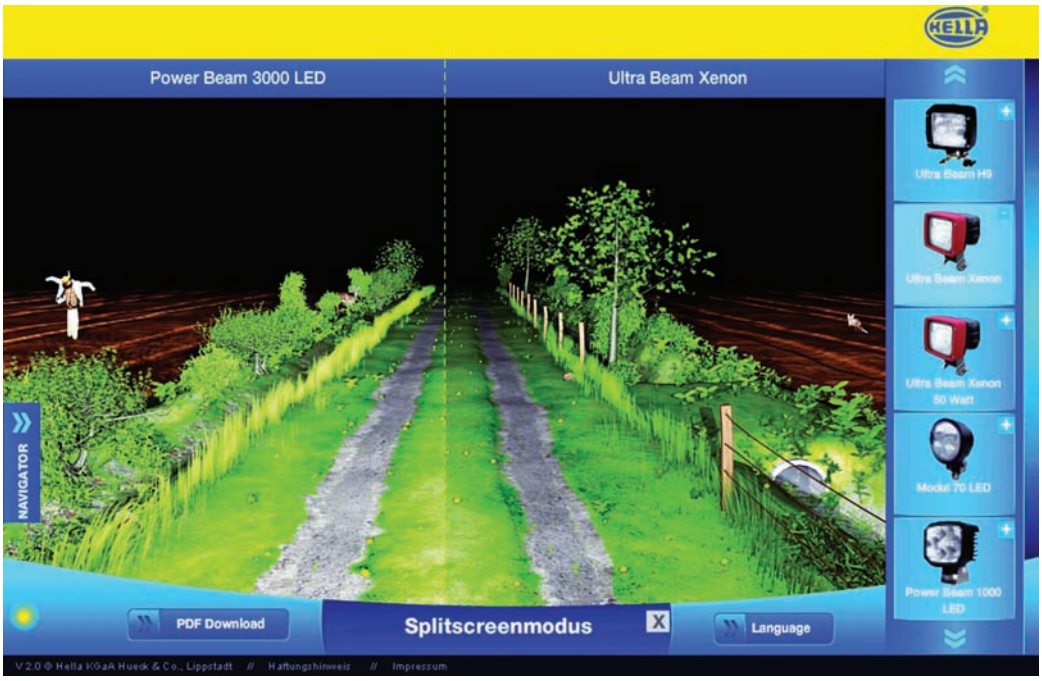
Software applications dedicated to light design will help to optimise the reflecting surfaces and therefore minimise the amount of light lost in the reflector and lens system. For example, to stay one leap ahead, Hella relies on an exclusive software called Helios, which enables an ideal design of the reflecting surfaces.

When the Power Beam 2000 LED work lamp was introduced as part of Hella's Performance Line of work lamps in 2010, its luminous power of 2,200 lumen already hinted that xenon technology might soon be overtaken.

Over the past couple of years, LED developments have eclipsed many of the benefits of xenon, one by one. Then in 2011, LED work lamps were finally able to technically outshine xenon technology. Hella presented its Power Beam 3000 to the market, pioneering a work lamp with a luminous power that measures more than 3,000 lumen.

However, the race for the top technological spot is decided not only by luminous power ratings but also by factors such as size, power consumption, design and life expectancy of the lamp. Now, for the first time, an LED work lamp, although more compact than conventional xenon models, outputs more light from the same amount of power consumed.

When comparing the Power Beam 3000 with a well-made xenon work lamp (2,700 lumen), there are striking



Compare different work lamps outputs at www.hella.com/eliver

and apparent visual differences in the type of visible light. These are not only due to its 10% greater luminous power but also to the higher colour temperature of the LEDs. To ensure the faithful reproduction of natural daylight, the Power Beam 3000's LEDs have a colour temperature of 5,700 K.

Because inefficient lighting can very quickly affect productivity, the quality of a work lamp essentially depends on choosing the right colour temperature. Adapting the colour range of these products to the needs of the human eye is therefore a key factor in the end user's productivity. As the human eye better perceives colours and contrasts at a colour temperature of 5,700 K than at the 4,200 K typical of a xenon lamp, LEDs require less measured luminous power to achieve the same visual effect.

The Power Beam 3000 beats with 72 lumen per watt (l/W) while a good xenon work lamp provides 64 l/W while consuming the same 42W of power. It is both metrologically and visually more effective. Replacing its high-performance solutions with low-input standard LEDs enables the design of even more energy-efficient work lamps, as Hella has been able to show in its Flat Beam LED (100 l/W) from the Efficiency Line of work lamps which, although not quite as compact, have a much lower profile.

The ageing process

For many years, the long life of the tube was one of the major selling points of xenon work lights. In general, life expectancies are specified as the percentage of failed light sources. Standard ratings are B3 (i.e. 3% of light sources failed after the specified timeframe), B10 (10% of light sources failed after the specified timeframe) and Tc (63.2% failed characteristic service life according to Weibull).

Light reduction, as suffered by xenon tubes, is not normally specified in the data sheets, but an average xenon tube loses up to 45% of its luminous power in the course of its life (B3=2,000 hours / Tc=3,000 hours). The same applies to LEDs, whose intensity of emitted light generally and continuously diminishes. This is called ageing or degradation and is caused by the migration or expansion of crystalline defects. Life expectancy ratings often describe the reduction as L70 (70% of the original luminous power is still available), a value that is often used to define the end of an LED product's service life.

When an LED work lamp generates light, up to 80% of the electrical energy consumed is converted into heat (xenon can be up to 85%). The heat produced during operation reduces the light output and shortens the life of the LED. If the maximum temperature is permanently exceeded, this will even destroy the semiconductor prematurely. This is why the thermal management of LED work lamps is such a crucial factor.

A thermal control system protects high-quality LED work lamps against LED destruction due to overheating. Hella, for example, equips its units with thermal sensors to measure the internal temperature. If this rises to a critical level, the power supply is reduced to protect the unit from overheating. All of Hella's LED work lamps feature this system. It protects the unit from damage, even when exposed to rising heat from the motor or to direct sunlight if the driver happens to forget to turn off the lamp.

Unlike xenon, LED work lamps never require servicing in the course of their life. The benefits of their compact design also makes them an even more viable replacement for halogen work lamps. Hella, for example, provides simple upgrade solutions for standard halogen models with work lamps from its Modular Line.

Hard cases

The long life of the LED lighting unit is only beneficial if the work lamp is sturdy enough to withstand external mechanical impacts. Mechanical requirements are particularly strict for agricultural and construction machines, where the units are frequently exposed to stones and gravel bouncing off the housing and lens; dirt due to sludge, dust, pesticides or fuels; pressure cleaning; and not least vibrations.

Hella responds to these demanding challenges by implementing a special software for simulation and analysis, and by only introducing products to the market that have successfully completed its tough testing and qualification procedures. To prevent the glass lens breaking, the company supplies its LED work lamps with optional plastic lenses made from nylon. These high-quality plastic lenses are particularly averse to external mechanical impact and are chosen for their advantages over normal plastic materials, which easily break, scratch or turn yellow.

The use of different electronic components makes it more and more

difficult to effectively compare LED work lamps. As well as thermal management, the electronic components mark the greatest difference in product quality. Very simple work lamps are provided with current-limiting resistors that turn 50-60% of the energy into heat. These solutions are generally a lot less expensive, but a major disadvantage must be considered: the light output varies with the power supplied because the diode current largely depends on the battery voltage. Even minor variations in the onboard mains will be apparent when an inexpensive solution is installed.

This is strikingly different when a linear constant power source is used. Its output current is virtually independent of the input voltage and the voltage drop across the consumer. Luminous power therefore remains stable even under varying onboard mains voltages. However, its rated heat loss of 40-50% does not make this a particularly efficient solution. The heat needs to be dissipated to retain the luminous power and to protect the life of the LEDs.

The most efficient solution is therefore a DC/DC converter that loses just 10-20% of the power. If this circuitry includes an optional microcontroller, this will allow for many additional functions, such as integration in the vehicle's electronic circuitry (e.g. LINbus), position finding by means of GPS, or automatic dimming to prevent glare.

Hella's high-performance Power Beam work lamps, for example, feature exactly this kind of microcontroller to provide a special control algorithm for adaptive power supply control as part of the thermal protection concept.

The DC/DC converter will reduce the power input before any overheating occurs. When the temperature has gone down to a normal level, full power will again be supplied to the LEDs. However, the more complex the electronic design, the greater any problems such as electromagnetic noise will be.

The increasing use of electronics in vehicles puts more and more weight on electromagnetic compatibility (EMC). So all devices containing electronic components must be designed so they do not disturb other electrical devices, assemblies or systems (emission), or are disturbed by them (immission).

In Europe, for example, only products that comply with the EMC Directive 2004/108/EC can be admitted to the market. Work lamp manufacturers can choose to either declare conformity themselves by affixing a CE mark on the product or have compliance confirmed by a type 'E' approval pursuant to ECE Regulation 10. As this approval certifies that the unit will not interfere with the onboard electronic circuitry, it is the perfect choice for vehicle use – and it will make it easier to obtain approvals for new vehicles.

A bright future

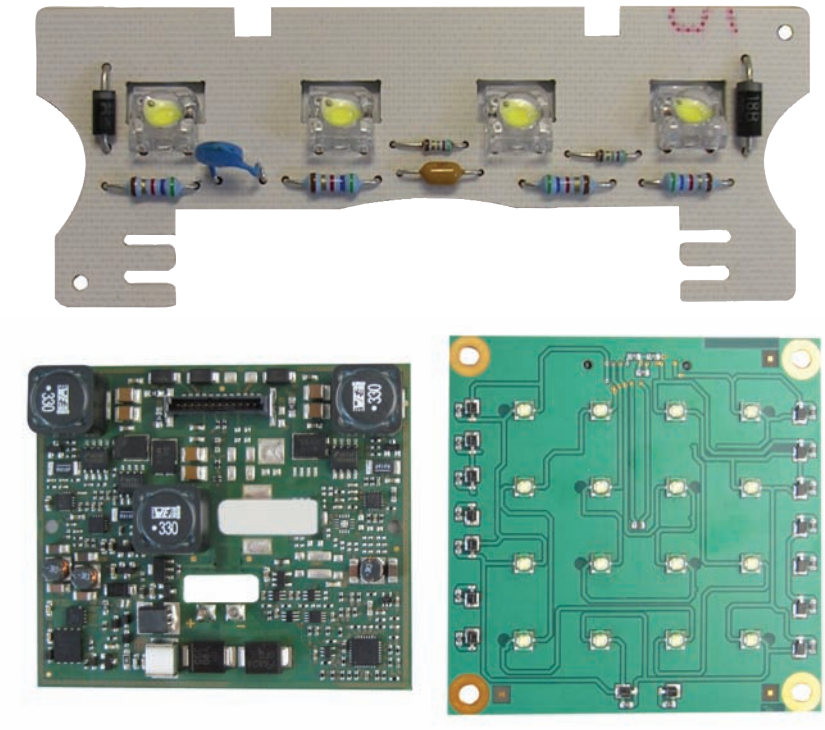
So now that the thermal problems have been solved in the course of LED work lamp design, the right LED has been chosen and well-matched electronic components have been installed, LED work lamps such as Hella's Power Beam 3000 have already outperformed their xenon predecessors. And the trend is still strong.

Hella Power Beam 3000 outperforms xenon lights with 3,000 lumen/43W

In November 2011, the company showed the next generation of LED work lamps at the Agritechnica fair. Examples include the extremely powerful Power Beam 5000 LED that extends its Performance Line, or the Oval 90 LED that extends the Modular Line. Simulated comparisons of the luminous power of various halogen, xenon and current LED versions from Hella's LED work lamp range can be viewed by using the Eliver Tool at www.hella.com/eliver.

"By 2015, many xenon customers will have migrated to LED alternatives," claims Stefan Maierhofer, Hella's work lamp product manager. "New LED work lamps will increasingly leave their xenon forerunners behind – there will be no advantages left to justify the use of xenon in work lamps.

"And the LED hype will go on for quite a while. The systems will provide more efficiency and power at a lower price. Other technologies, such as OLED (organic light-emitting diode), LEEC (light-emitting electrochemical cell) or optical fibre solutions are either too inefficient or not currently powerful enough to find their way into work lamp products. But the future is holding many interesting innovations in the field of LED lighting technology." **iVT**



Highly sophisticated DC/DC converter (above) versus a simple inefficient resistor solution (top)

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