Auto Headlamp Designed to Save Energy, Weight, and Money

Covestro developed a monomaterial, multishot design that dramatically reduces part numbers

By Robert Grace

Covestro wants automakers to see the light when it comes to headlamps.

Through the adoption of a creative monomaterial strategy, combined with multishot molding and in-mold assembly, the Leverkusen, Germany-based advanced materials supplier says it has developed a multifunctional vehicle headlamp with numerous benefits. It slashes the number of components from as many as 60 to five, is significantly less expensive to manufacture, weighs less, and even is more sustainable than current models.

Covestro's design concept involves extensive use of polycarbonate (PC), including the firm's Makrolon TC 8030, a high-end, thermally conductive PC grade, which enables the replacement of aluminum heat sinks with the molded material, explains Paul Platte, a senior marketing manager in the automotive and transportation sector of Covestro's U.S.-based operations in Pittsburgh.

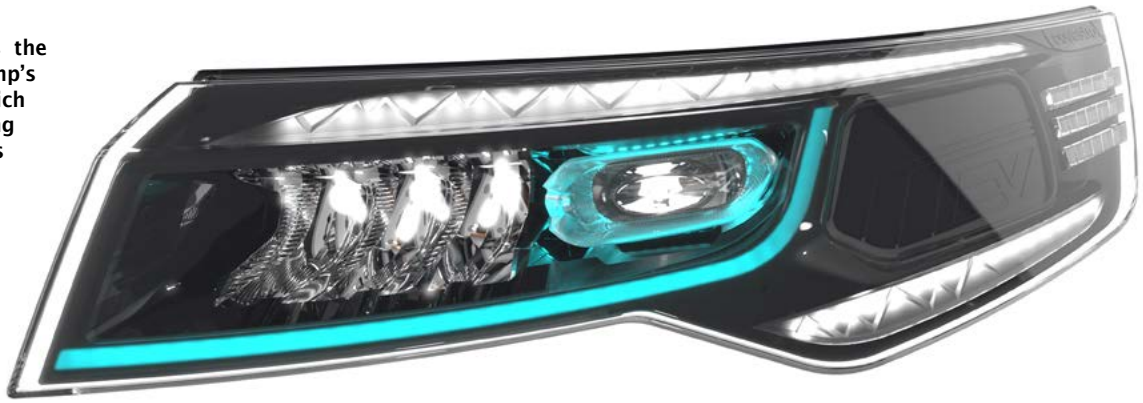
An interesting factor, he notes, is Covestro's engineers replaced metal with plastic in large part for heat-management purposes—not for the typical automotive reason of trying to reduce weight. Still, each new headlamp can weigh up to nearly 4 pounds (1.8 kg) less than today's typical products.

The other driving force behind using multishot molding is part consolidation, resulting in the elimination of dozens of screws and other components—such as the four cast-aluminum heat sinks—and an overall reduction in complexity and assembly. The new design concept requires 18 fewer process steps than today's typical headlamp, including eight fewer assembly operations.

Saving Dollars, Not Cents

Jim Lorenzo, Pittsburgh-based principal engineer in Covestro's application development group, conceived the headlamp concept's design and the manufacturing process, which uses three-shot injection molding for both the housing and the bezel, and a single shot for the transparent outer lens. It's this use of multishot molding that creates the opportunity for significant cost savings.

Covestro's multifunctional, mono-material headlamp design leverages thermally conductive PC to eliminate heavy, costly aluminum heat sinks, while using multishot injection molding and in-mold assembly to simplify production and lower cost. Courtesy of Covestro



This rendering highlights the teal color of the headlamp's optional styling bar, which Covestro envisions being used to alert pedestrians that a vehicle is in autonomous mode. Courtesy of Covestro

Covestro's new headlamp has undergone intensive analysis by Intellicosting LLC, an independent engineering consulting firm that provides comprehensive cost benchmarking services, according to Platte—and he claims the results so far are impressive. Depending on the component configuration, an automaker can save between $3.00 and $4.76 per headlamp, or twice that per vehicle, he says. And this in an industry where weight and cost savings typically are measured in grams and cents.

The design has 60 fewer parts, requires 19 fewer operations to produce, is 2 to 3 cm thinner, weighs 1.8 kg less, and costs nearly $5.00 less per headlamp. The monomaterial approach makes the headlamp more recyclable at end of life. Courtesy of Covestro

Intellicosting initially did its analysis and cost estimates in U.S. dollars, based on U.S. labor rates. Covestro asked it to go a step further and apply the same assessment based on labor rates in Japan, China, Germany, and South Korea, and says it is finding similar outcomes of savings there, although it varies somewhat from country to country.

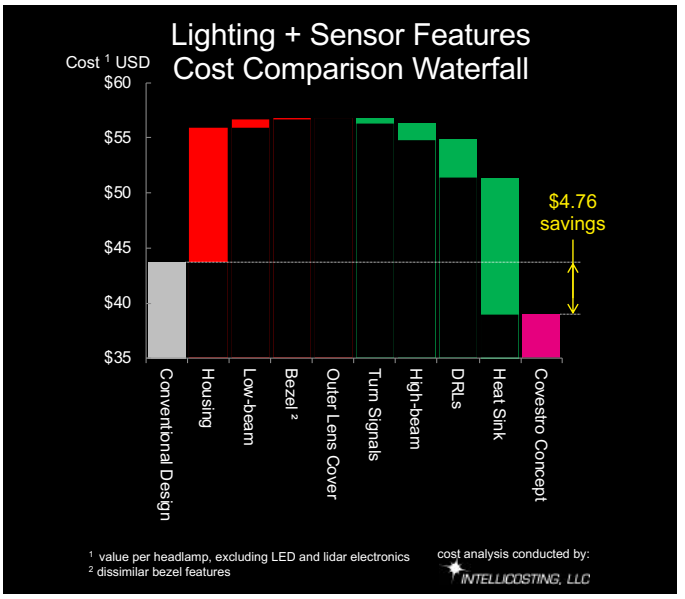
Lorenzo designed the headlamp in late 2018, working in conjunction with Pittsburgh's Bally Design studio. The tooling was built in mid-2019, with the whole project largely being conceived and built in a year. Covestro also worked with three lighting companies, who served as coaches and collaborators. "They kept the design plausible," Lorenzo says.

New Features Equal New Design

The growing use of LED lights, meanwhile, creates the need for new thinking in vehicle headlamp design, says Platte. Compared with traditional designs, LEDs generate high heat in new places and reduced heat in other areas, he notes. Covestro's concept installs its LEDs via in-mold assembly into the housing using thermally conductive resin. And, while the roughly 60-second molding cycle time is similar to that of current designs, the mold needs to be held open longer to allow for the in-mold assembly of the LED lights and electronics.

Emerging technologies, such as autonomous vehicles, are creating a need to incorporate all types of new sensors, lidar and radar components, and cameras into the compact space that previously housed simply a headlamp. Many of these components require their own heat sinks, which Covestro's design integrates directly into the housing via multishot molding potentially saving 2 to 3 cm in headlamp depth.

All this needs to be done with sleek styling in mind. Covestro designed styling elements below the low-beam and around the high-beam elements of the headlamp that would allow LED lights, possibly teal color, to be used in the future for communicating with pedestrians—for example, a flashing of that color light could indicate



This graph offers a comparison, verified by Intellicosting LLC, of the reduced cost of Covestro's headlamp to a similar surrogate headlamp made with typical materials and processes. It suggests a total savings of more than $9.50 per vehicle. Courtesy of Covestro

to a pedestrian that the autonomous vehicle sees him or her.

Lighting colors on vehicles are tightly regulated, Platte notes. And other than amber turn signals, colored lights are not currently allowed on the front of cars. To communicate with pedestrians that the vehicle is in autonomous mode, some in the industry are lobbying for teal as the color to indicate autonomous driving mode.

Currently, cars on the road are moving more and more to having only LED lights in the front. Simply replacing current headlamp constructions with Covestro's monomaterial molded version (without additional sensors, lidar, or styling features), still would save automakers nearly $3.00 in cost and 2.87 pounds (1.3 kg) in weight per headlamp, Platte says.

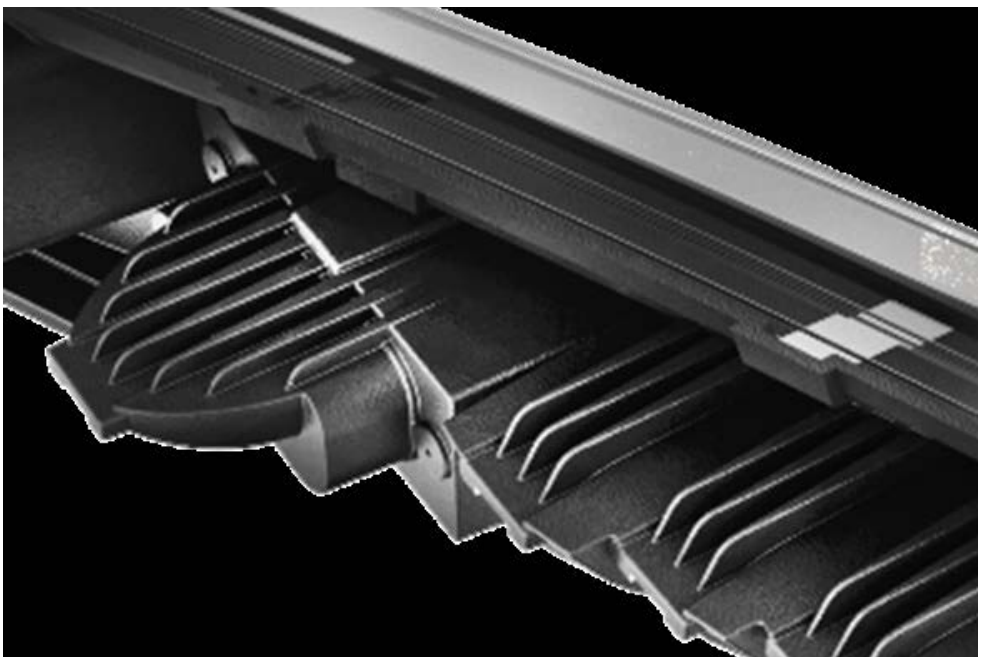
Target Is Electric Vehicles

Covestro developed its design concept initially with electric vehicles in mind, Platte explains. This is because PC can be susceptible to some types of chemicals and oils that exist in gas-powered internal combustion engines (ICE).

"We're looking for a way to protect the back of our module from chemical exposure," he says, which would enable the new headlamp design to function equally well with ICE. "We're also seeing some OEMs looking closely at the balance between the extent of this potential exposure compared with the potential cost and weight savings involved."

As for the injection molding process involved, a 1,200-ton press was used for the cost analysis of the housing component. That large a press was chosen not for the clamping pressure, Platte stresses, but to provide the necessary space to accommodate having three barrels coming into a two-cavity tool. The third barrel is needed to provide a laser welding bead of Covestro's Bayblend PC+ABS for the laser welding of the PC lens to the PC housing.

While the two-cavity tool is complex and expensive, only one tool is needed, as opposed to multiple tools for the different components in a traditional headlamp, leading to an overall reduction in capital required.



This back view of the Covestro headlamp shows the molded-in heat sinks made of Makrolon TC 8030 resin. The high-beam heat sinks are on the left; the three sets of three fins on the right represent heat sinks for the low-beam lights. Courtesy of Covestro

The added sustainability factor is also a key success, Platte says. The resulting headlamp saves weight and is recyclable since it is a monomaterial construction. Citing the United Nations Sustainable Development Goal #12, Platte adds the new headlamp design also requires less equipment to produce, fewer parts, and consumes less energy to manufacture and to transport. With this design, less is more when it comes to product benefits.

In addition to the housing, different PC grades are employed to good effect elsewhere in this concept. Makrolon LED2445 ST is a sensor-transparent PC grade that provides the transparency needed for lidar signal transmissions. And Makrolon DS801 is a dimensionally stable grade that is used for the second shot, in combination with so-called vario-thermal mold control, in the two-shot reflector housing. This provides low surface roughness that is directly metalizable and leads to a highly efficient reflectivity of visible light. The dimensional stability is vital because it enables a beam pattern performance that remains stable throughout the operating temperature of the LED lamp system due to its low, isotropic thermal expansions.

Polycarbonate, Platte asserts, is the only material that allows development of a headlamp system like this, since it can be transparent, thermally conductive, sensor transparent, directly metalized, colored or diffusive, and laser weldable.

The key message, Platte says, is that "you don't need to wait to achieve these weight and cost savings. We can do so today with LED headlamps, all because of a monomaterial strategy that enables part consolidation through multishot molding and in-mold assembly."

ABOUT THE AUTHOR

Robert Grace is a writer, editor, and marketing communications professional who has been active in B2B journalism since 1980. He was founding editor of and worked for 25 years at Plastics News, serving as editorial director, associate publisher and conference director. He is now both editor of SPE's *Journal of Blow Molding* and a regular contributor to various outlets. A long-time member of the Industrial Designers Society of America, he runs his own firm, RC Grace LLC, in Daytona Beach, Fla., and can be contacted at bob@rcgrace.com.