

# Light Minded



**Lightweighting internal combustion engine castings is front and center for automotive parts-makers and the foundries that serve them. And don't look now but shaving pounds off electric vehicles is a big priority, too.**

*KIM PHELAN, CONTRIBUTING EDITOR*

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he complexities of designing, developing, casting and post-processing an automotive component are much like the making of music—a collaborative, harmonious effort among many skilled professionals, but the automotive industry is beginning a new overture.

Linamar Senior Metallurgist Remi Martinez likes to think of castings in this metaphorical way, even as automotive makes a slow transition from internal-combustion-engine vehicles (ICEVs) to electric vehicles (EVs). The evolution will find foundries morphing

and honing their expertise to meet the changing demands of OEMs, or, in some cases, diversifying their businesses toward other sectors in the long term.

But for the next two or three decades to come, castings in ICEVs are not only safe from extinction, they'll continue getting lighter and performing better.

Today, EVs represent roughly 5% of on-road vehicles, and the adoption that will fuel their growth in North America faces

numerous obstacles, meaning their phase-in could more resemble a slow trickle than the flood some would like to see.

Whether they climb to the 50% mark in 10 years or 20, and then to greater marketshare after that, more EVs will ultimately mean fewer castings for the automotive sector, period. As more OEMs and parts manufacturers join the roster

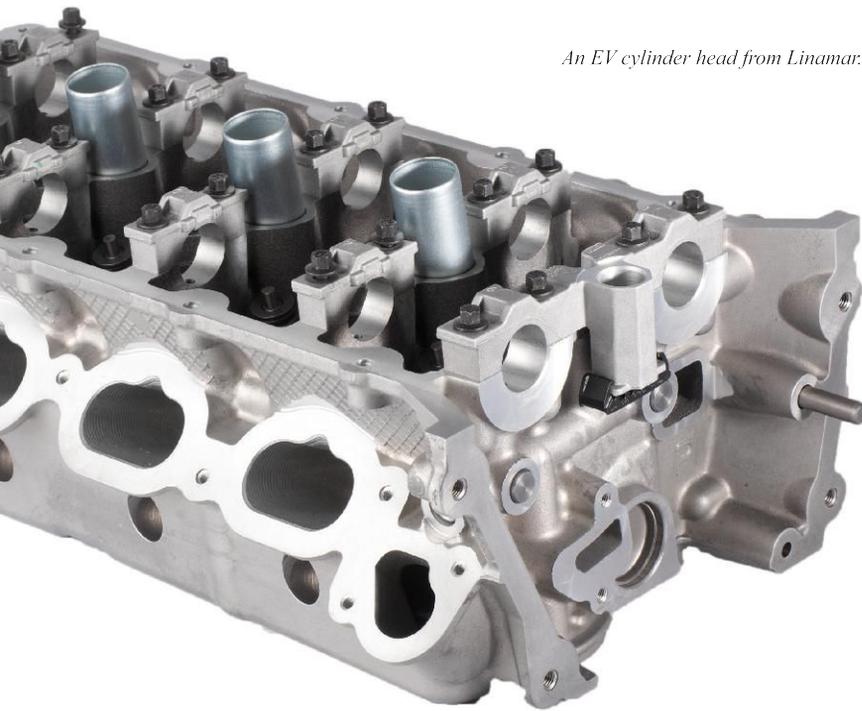
of companies shifting most or all R&D investment to EVs going forward, it might seem the die's been cast for a dim ICEV future, but the game's far from over for ICEVs and their myriad castings.

"ICE vehicles are not going away anytime soon," said Mick North, CEO and president at Anderson Global, a tooling and casting solutions company whose business is currently 95%



*An EV shock tower from Linamar.*

An EV cylinder head from Linamar.



metal castings in the U.S. over the next five years.

### Lighten Up

Testifying to their own fight for life, ICEVs boast recent improvements in efficiencies, notably the advent of turbo technology that has packed more power into a smaller package with the use of compressed air in combustion, said AFS Member Andrew Halonen, owner of Mayflower Consulting LLC that concentrates on the auto sector. In fact, the biggest efficiency in engines overall, he said, has been the downsizing trend.

With turbo global sales numbered at 45 million, it's been a significant innovation for ICEVs, he added—and the number will increase. “You're going to see turbos in essentially any IC engine whether it's the smallest motorcycle to a ship.”

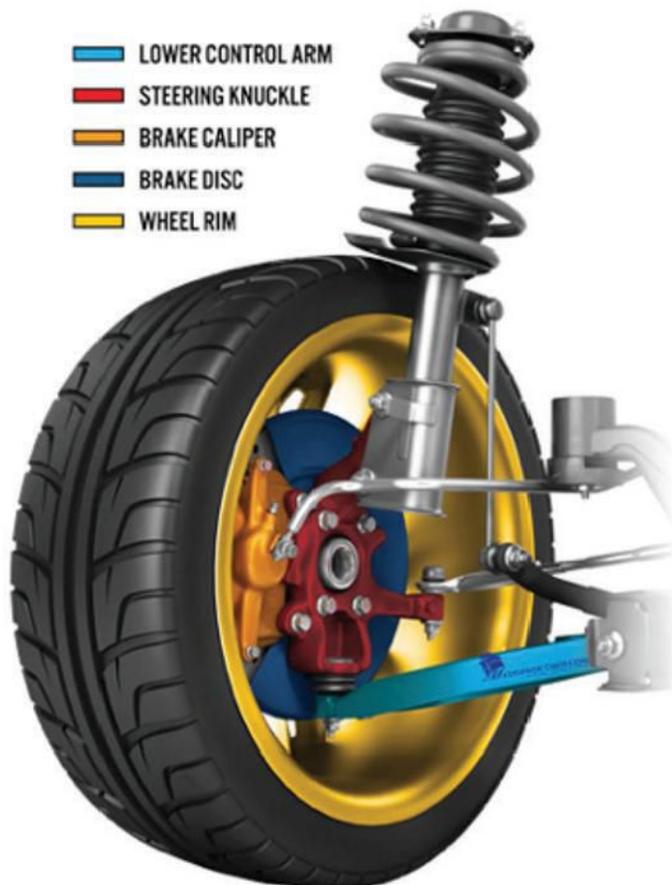
automotive. “A couple of years ago, there was a whole rush of blood in the media that we'd all be electrified by 2025, and that's absolutely not going to happen.

Is it going to happen eventually? Yes. It's just a function of what you think the timeframe is ... And it's going to depend on different markets—Europe's different from Asia, which is different from the United States.

“Ultimately, ICE vehicles are not going away completely, but there's going to be a significant switch. Any way you cut it, there will be less castings. We can already see that the amount of new vehicles being developed in the EV space is massive. Even as recently as the end of September, Ford's announcement of \$11 billion to be spent on battery manufacturing in the United States tells you where it's going.”

While convinced the change is relatively far off, North is nonetheless executing a deliberate diversifying shift into new sectors to reduce

the company's dependence on automotive when ICEV work contracts. He said he's also confident widespread reshoring of manufacturing will ignite major growth of



Where ICEVs get the most engineering attention these days is in lightweighting. But what happens in ICEVs won't stay in ICEVs—quite a bit of the reduced-weight castings on ICEVs will be relevant for EVs, as well, according to Halonen.

Would OEMs go out of their way to make components lighter if not compelled by regulations such as Corporate Average Fuel Economy (CAFE)? Probably not, Halonen said, but a number of benefits do emerge from the effort. And the lighter ICEVs go, the longer they're apt to stick around to give EVs a run for the money.

Benefit No. 1 of lightweighting is the obvious fuel efficiency that translates to less

A number of ICEV castings remain relevant in EVs.

# Benefit No. 1 of lightweighting is the obvious fuel efficiency that translates to less pollution.

pollution. Industry insiders, including North, acknowledge that global standards around greenhouse gas emissions reduction will only increase, making better fuel economy extremely important.

“One of the levers you can pull is weight of the vehicle,” he said. “There are other technologies, such as stop-start technology, hybridization, and increasingly sophisticated software controls in the engine, but the weight is a big one. I’m not sure exactly where it ranks, but it’s got to be close to the top of the most important things.”

A byproduct of being incentivized by the persuasive arm of federal regulation and taxation is that manufacturers have to think in terms of tradeoffs as they consider “payload” that consumers desire in new vehicles. Maybe that’s a heated seat, or big screens on the dashboard, or airbags all over the vehicle, or more sensors, said Halonen. The key is balancing weight to stay within a certain tax category, so a pound of every bell, whistle or safety feature added means the removal of a pound of something else, which is where lightweighting a casting comes in.

## Decisions, Decisions

The rationale for lightweighting can be very subjective, driven by human personalities and preferences, making the layers of vehicle decision-making much like the proverbial onion, according to Halonen. In the end, however, it usually comes down to cost, not just weight, he said.

“Look at the 2020 Ford Explorer,” he said. “They spent a bunch of money on weight reduction and some of those are castings, like the shock towers. However, they switched their front knuckle from a cast aluminum knuckle in 2017 to ductile iron in 2020 and they probably added as much as 10 lbs. to

the vehicle. But ductile iron is much lower cost than cast aluminum, so it was clearly a cost savings play at the expense of weight.”

Far from arbitrary, weight specifications are determined by a number of considerations, including the tradeoffs for new features. But ironically, the latest model of an ICEV probably won’t be reinventing the wheel, figuratively speaking—because the weight of castings sometimes is set by the part’s predecessor.

“The baseline is the prior component,” said Halonen. “A lot of people have the impression that OEMs have an abundant amount of resources to go and evaluate the best way to make something. In reality, the opposite is true most of the time. If they’re going to do a vehicle refresh, they have a very short amount of time to make a design decision and which direction they’re going to go to complete that design, get the prototypes, get vehicles tested on the track, get them signed off, get tools made, and go into production. The whole timeline is so compressed that they very seldom have the luxury to say, ‘Should this knuckle be cast out of this or forged out of that?’”

Naturally, parts manufacturers take their marching orders from their OEM clients, although there’s a give and take behind the scenes on how to achieve the final goal.

“Let me give you an example,” said Martinez. “Quite often we have to work with customers on redesigning the part locally because when we do our development, we realize that the cross section in that area is not large enough, and we’ll have creational defects when we do the casting process. If that area is not functional for the part, we usually have the green light to optimize it to make it more casting-process-friendly. But if we have to add weight, we have to find another

area where we gain back the weight. We have to stick with the numbers which are given to us. We have to work around the number and we have no flexibility.”

## Weight Problems

Manufacturer and foundry engineering teams must collaborate to solve the ongoing puzzles associated with taking weight out of castings. Sources concurred that foundries require more than specifications and a part sample in order to excel as problem-solvers, meaning they should be provided with the full gamut of functionality, including its mechanical loads. Seeing the adjoining parts around the casting being ordered is basic, too. Without this level of context, foundry engineers are like the proverbial blind men surrounding an elephant, each able to describe the beast based only on the single body part they’re able to touch.

Design and casting experience is the most powerful resource collaborators have at their disposal, said Martinez, but the right machinery and processes are essential, especially to solve the biggest challenge of all.

“Any cast part is a puzzle,” he said. “You can have small foundries that are making extremely complex parts using, for example, investment castings, but they will make perhaps 10 parts a day. And that’s extremely complex, because the process is complex, the geometry is complex. Now, if we switch to mass production, it’s not only a matter of the casting process alone. Take cylinder heads as an example—making millions of heads with the same quality and the same material and the same geometry a year, millions a year, it strains so many different areas of expertise: the foundry, coring, heat treatment, machining, dimensional control, logistics and others.”

Ensuring the perfection of every lightweighted part at dizzying volumes hinges on flawless machine performance, and Martinez is adamant when he points to the most crucial thing a foundry must do to consistently fulfill their side of the casting bargain: continuous

preventive maintenance.

Beyond uptime for existing equipment, many U.S. foundries could use a healthy shot of high-tech investment, according to North.

“Lightweighting requires thinner wall sections—these are complex castings,” he said. “If they’re structural components,

they have to be heat treatable aluminum, which means they have to be virtually zero porosity, and if they’re automotive, they’ve got to be low cost.

“You’ve got to have a very high level of casting process control,” he added. And you’ve really got to have the latest technology that

gives you a much better process control, much better cooling capability, and allows you to do center walls, low porosity, heat treatable castings; you get thinner and thinner walls and hollow sections. Now, you’re lightweighting and you’re capable of casting things in aluminum that you would have

## EVOLVING TO A LIGHTER FUTURE

EV by definition doesn’t equate to being lighter than their ICE counterparts, and as R&D pours into electrification, manufacturers are, among other improvements, focusing on how to lightweight their electric models.

Automotive consultant Andrew Halonen compares the size of an EV battery box to a big mattress that weighs between 1,000 and 1,500 lbs. depending on the size of the vehicle. Because OEMs put as much as they can into battery packs to extend length of range on a charge, he said, density is high and weight is high.

“If you compare the Ford Mustang to the Mustang Mach-E, the Mustang Mach E is 1,000 lbs. heavier,” he said. “Or look at the electric version of the Ford F 150, Lightning—I don’t think it changed much in terms of its footprint, but every day of the week the thing is at least 1,000 pounds heavier. The loads on a lot of these parts went up. So, what are

they going to do about it? How are they going to redesign those parts?”

Remi Martinez, senior metallurgist at Linamar, also acknowledged limited range is one of EVs’ greatest drawbacks in the market, but increasing range has the downside of beefing up weight.

More weight affects the kinetic energy of a car—the heavier the vehicle, the greater its kinetic energy as the car travels at high speed on the highway, Martinez explained. And higher kinetic energy means higher potential damage in the event of an accident.

“You want to keep those cars as light as possible to make them safe for the people who are driving and for the pedestrians who could be hit by those cars in the city,” he said. “There are many, many driving forces to lightweighting EV cars.”

Watch for casting innovations in EVs that will contribute to solutions in the weighting game. **CS**



Photo credit: media.ford.com

had to use ductile gray iron for in the past—and you can get there with equivalent cost.”

### Alternatives

Investment in the level of sophistication North described comes at a steep cost, one that puts small foundries at a disadvantage. But innovation can help.

“We are working with some customers using much lower-cost tilt-pouring machines with lower-cost tooling to make components equivalent to high-pressure thinner walls,” said North. “We have casting designers here, so we’re helping [customers] design for manufacturing those components with thin walls and low-porosity requirements for tilt-pour equipment that probably makes economic sense for lower vehicle volumes.

“... There might be an opportunity for permanent mold gravity-fed solutions or low pressure rather than

a very expensive high-pressure tooling,” he added. “That’s something we’ve been working with a lot.”

North said a mid-October automotive conference he attended affirmed both directions. “One big takeaway for me was that there will be a proliferation of relatively low volume vehicles. This means that Anderson Global’s ability to convert expensive high-pressure die cast components into low pressure or even gravity permanent molds could become very important.”

Alloys certainly factor into any conversation about lightweighting, and some novel developments in alloys have potential to help foundry-manufacturing partners achieve weight reduction—but changing alloys cannot be entered into lightly. Introducing a new alloy in the foundry can wreak havoc on its operations, especially when compounds in new ingots cannot in any way mix with existing metal in the

plant. New, unexpected outcomes can also crop up by merely pouring a different alloy than what’s previously been used for a given part.

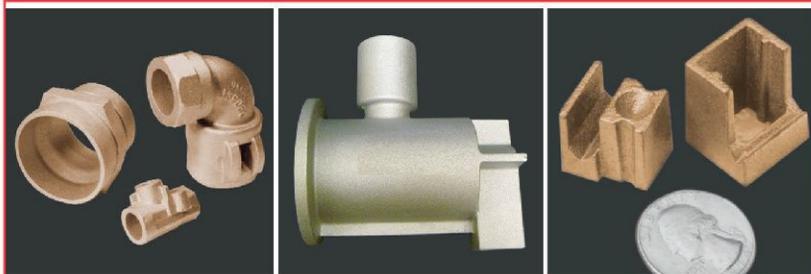
“When you switch from one material to another or from one heat treatment to another because you want to improve your lightweighting part, most of the time you are going to change the state of residual stress, particularly if you change the heat treatment recipe, and you cannot quantify it easily; you don’t see those stresses easily,” said Martinez. “And the way you can measure those stresses is actually complex, expensive and time consuming. A new alloy can play a role in the fatigue performance and the strength of your part; and, to some extent, also on the distortion of your parts—you can make a part that will have lots of stresses and then you start machining the part and it will warp right in front of you. The balance between all of those little details is very complex.”

### Find Your Lane

Despite the fact that quite a few castings on ICEVs will be relevant on EVs, according to Halonen, someday—when engine castings are in less demand than today—foundries that have played in the IECV space will have to either redefine themselves for EV work or move on to different sectors to replace whatever slice of business goes away.

“I would steal a line from the ‘Shark Tank’ show, and that’s ‘find your lane,’” said Halonen. “Think about what you’re really good at and just absolutely capitalize on it. Of course, you have to adjust to the market, so if you’ve been really good at cylinder heads and then your customers are asking for fewer and fewer cylinder heads, then take that capability and go find the space. It might be a motor housing, a hollow subframe, or lower control arm for an electric pickup or something like that, yet instead of trying to be everything to everybody, do what you’re really good at and continue to hone that skill.” **CS**

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