New opportunities for hybrid-specific lubricants on the road to a more sustainable world

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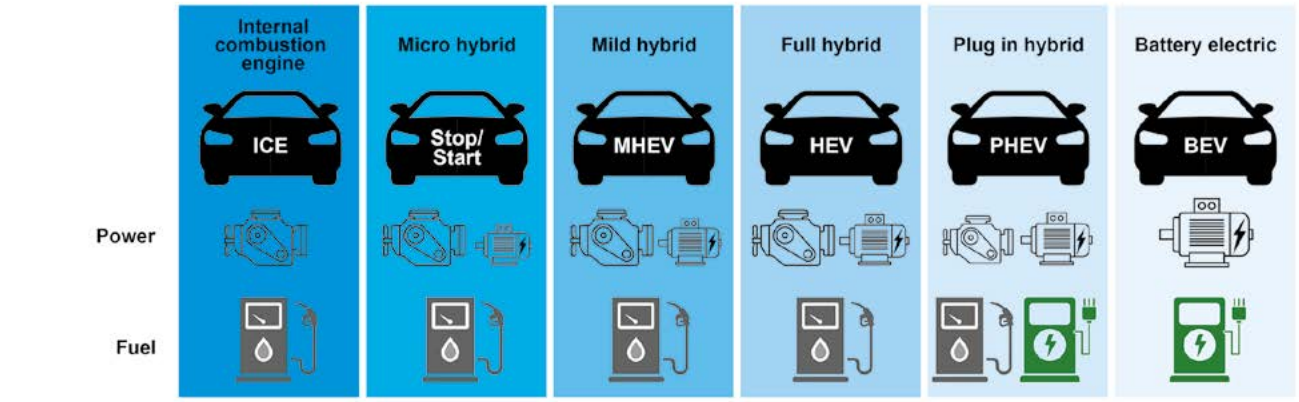
As more automotive manufacturers commit to a net-zero emissions future, the pace of powertrain electrification is accelerating. But, while we wait for better recharging infrastructure and for consumers to fully embrace battery electric cars, hybrid architectures are helping OEMs start their emissions reduction journey today. Although hybrid technologies are well-established, OEMs are working to improve their efficiency even further, which means their lubrication requirements are changing. This article looks at some of the challenges that have been identified and at the opportunities these create for lubricant marketers to create hybrid-specific engine oils to satisfy this fast growing segment.



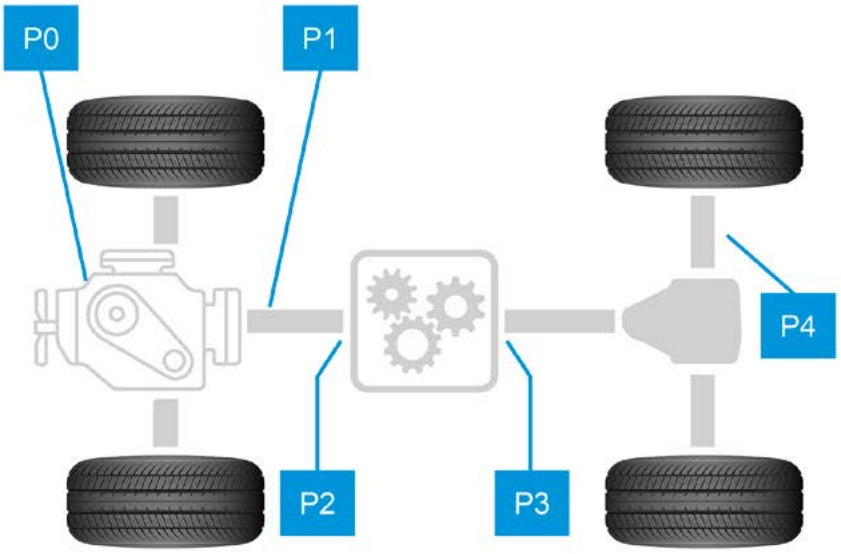
Hybrid complexity increases

ICE used for propulsion	✔	✔	✔	✔	✔	✘
e-motor used for propulsion	✘	✘	✘	✔	✔	✔
Braking energy recovered	✘	✘	✔	✔	✔	✔
Example 2022 models	Toyota Corolla XLE 1.8L auto	Toyota Prius AWD 1.8L auto	Toyota Corrola 1.8L auto	Toyota Prius Eco 1.8L auto	Toyota Prius Prime 1.8L auto	Tesla model 3
*CO_2 g/km	170 g/km	111 g/km	105 g/km	98 g/km	48 g/km	0 g/km
*Fuel consumption	7.4 l/100km 32 US mpg	4.8 l/100km 49 US mpg	4.5 l/100km 52 US mpg	4.0 l/100km 59 US mpg	133 MPGe 4.3 l/100km 55 US mpg	132 MPGe

*Data source www.fueleconomy.gov

Fuel consumption CO_2 emissions decrease

Note - Toyota models are shown as an example only - other hybrid vehicles are available



P0 the e-motor is connected to the crankshaft via a belt

P1 the e-motor is bolted to the rear of the crankshaft

P2 the e-motor is mounted on the input of the transmission

P3 the e-motor is mounted on the output of the transmission

P4 the e-motor is connected through a gear mesh on the rear axle of the vehicle

Not all hybrid cars are created equal. Although many of the models in OEM line-ups are now carrying a hybrid logo or sporting their distinctive electrified branding, not all of them employ the same propulsion systems to drive the wheels. Before we explore the penetration of hybrids into the passenger car market it is important to understand just what all the industry jargon applied to hybrids really means. From start/stop, mild hybrids (MHV) and full hybrids (HEV) to plug-in hybrids (PHEV) and full battery electric (BEV), the graphic below gives a high level overview that explains some of the differences between the hybrid architectures.

On top of these basic differences there are also numerous hybrid system configurations: P0, P1, P2, P3, P4, which define the position of the electric motor (e-motor) in the vehicle. In ascending numerical order these systems offer better emission reduction but become more complex and costly.

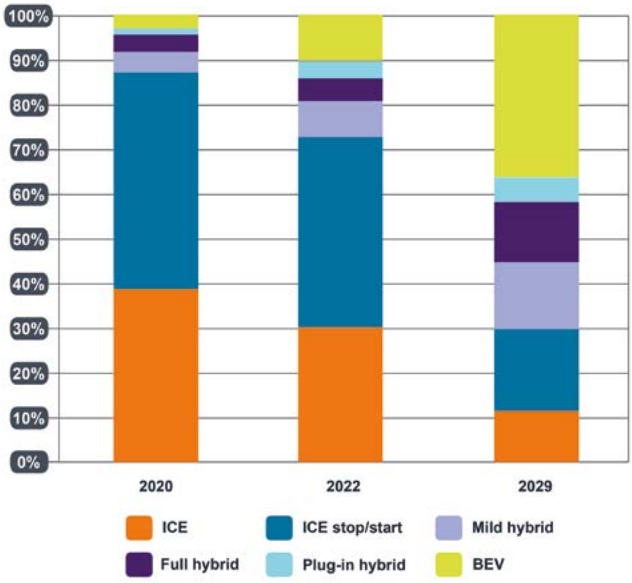
A growing hybrid market

Clearly emissions legislation and OEM commitments to net-zero are driving the electrification of light-duty vehicles.

Hybrids, or electrified internal combustion engines (e-ICE), are well-established in the market and have demonstrated their ability to provide significant reductions to overall emissions. Coupled with low carbon fuels, hybrid technologies will be an effective complement to BEV in meeting increasingly demanding CO_2 emissions targets. We expect most OEMs to include more full and plug-in hybrids in their portfolios as they transition away from the internal combustion engine.

However, despite being identified as a bridging solution, hybrid technologies have the potential to retain a large market share for many years to come. And, in the near term, the vehicle powertrain production mix will be spread across many propulsion systems; from the conventional ICE-only, through various degrees of hybridisation, to full BEV.

Global production forecasts of light-duty propulsion systems



Source: S&P Global, Light Vehicle Powertrain & Altern. Propulsion Forecast, August 2022
If you would like to learn more about this forecast data please contact S&P Global (sarah.graham@ihsmarkit.com)

What we can see is a reasonably fast growth in hybrid production from 2020-2022 to meet orders from early adopters. Looking ahead, what we can expect to see by 2029 is that BEV along with mild, full and plug in hybrids will account for almost 70% of worldwide light-duty vehicle production. In this same timeframe, hybrids containing a combustion engine

(including micro hybrids) will account for around 50% of vehicles produced, while those hybrids that can employ the e-motor for propulsion will account for almost 20%. Rapid adoption of 48V mild hybrid architectures could quickly change these projections, offering new options for electrification of the ICE and a replacement for less efficient stop start systems.

Longer-term, vehicle electrification trends predictions are hard to make owing to the level of uncertainty of green deals and other government and industry initiatives. One thing that seems clear is that with average vehicle age trending older, these vehicles will remain as part of the global car fleet for several years to come.

Hybrid lubrication trends

Currently, OEMs tend to recommend conventional passenger car motor oils (PCMO) for their hybrid models and have not introduced hybrid lubricant specifications. However, many OEMs do make specific recommendations for their vehicles on viscosity grades or oil drain intervals (ODI). For example, one OEM recommends SAE XW-40 and another has recommended an ODI of around half of that recommended for its conventional ICE.

OEMs in the US generally recommend SAE 0W-20, API ILSAC GF-6A and the newer SAE 0W-16, API ILSAC GF-6B grades and API quality levels. However, none of the ASTM engine tests used to qualify lubricants for the latest API specifications are designed to simulate the special hybrid duty cycles, which these vehicles often operate under.

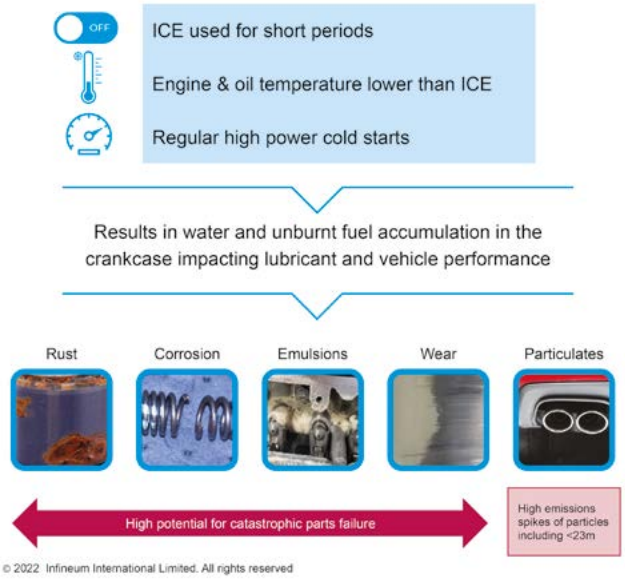
In Europe, although ACEA has recently upgraded its light-duty specifications, they do not include any hybrid-specific tests. However, some European OEMs, recognising hybrid-related issues, have built tests into their latest specifications, with more believed to be on the table for consideration. While in China and Japan, the desire to incorporate specification requirements to protect hybrid vehicles into passenger car lubricants is also a serious topic of discussion.

But, as e-ICE technology advances, and the use of stop/start systems diminishes in favour of more complex systems, the environment is becoming very challenging for conventional lubricants. Each of the more advanced e-ICE configurations are different in their pattern of operating cycles and will challenge the lubricant in very different ways compared to a standalone ICE.

Hybrid lubrication challenges

One of the key challenges in the lubrication of HEV and PHEV is the nature of the hybrid drive cycle. In these architectures, since the e-motor can drive the wheels, the ICE can stay off completely or be used to supplement the power of the e-motor under certain driving conditions. This means the engine operates for only short periods and the oil temperature is much lower than in a conventional ICE-only vehicle or more basic hybrid architectures. These persistent low temperatures are raising concerns regarding the ability of conventional PCMO to sufficiently protect the e-ICE. Specifically we are seeing issues with the accumulation of water and unburnt fuel in the crankcase, which can result in lubricant emulsions, rust and corrosion along with increased bearing, valve train, cylinder and liner wear – all of which have the potential to cause catastrophic parts failure.

In addition, the engine performs a number of high-power cold starts, which create much more engine stress due to the rapid application of a high engine load. The concern here is the occurrence of particulate spikes, especially the concentration of very small <23nm particles. Maintaining the effectiveness of advanced aftertreatment systems over the entire vehicle lifetime will become increasingly important to ensure emissions compliance.



Today's hybrid vehicles rely on lubricants meeting specifications that were developed for ICE-only duty cycles. However, research indicates that the more

complex e-ICE configurations benefit from hybrid-specific engine oils that have been tuned to meet the challenges presented by the different operating conditions encountered. There is clearly now a compelling case for hybrid-specific test methods to be developed that more closely mimic the hybrid duty cycles, lower temperature and high power cold starts encountered in these vehicles.

Hybrid-specific engine oil opportunities

Increasingly complex hybrids, with more advanced engine technology and after-treatment systems will become a bigger part of the vehicle market in the coming years en route to full electrification. Their very specific lubrication requirements are expected to drive the demand for a next generation of targeted lubricant formulations. While the nature of demand will partly depend on OEM decisions on ODI, those lubricant marketers ready with proven hybrid-specific formulations will be well placed to satisfy the needs of this new and rapidly growing segment.

As the market evolves, the impacts of new fuel types, the introduction of lower viscosity grades and the need to protect advanced after-treatment systems may drive the need for new tests and revised limits in current ICE specifications. Questions remain on whether e-ICE specifications will emerge or if e-ICE dedicated tests will be progressively incorporated into existing OEM and industry specifications – but such activity would further support the growth of hybrid-specific oils.

Infineum has been working closely with OEMs, oil marketer customers and other industry partners to gain a comprehensive understanding of these hybrid challenges. Our work has shown that advanced lubricant solutions with performance tuned to the hybrid drive cycle can deliver specific benefits in hybrid applications.

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