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FUEL ECONOMY

Crankcase lubricants have an important role to play

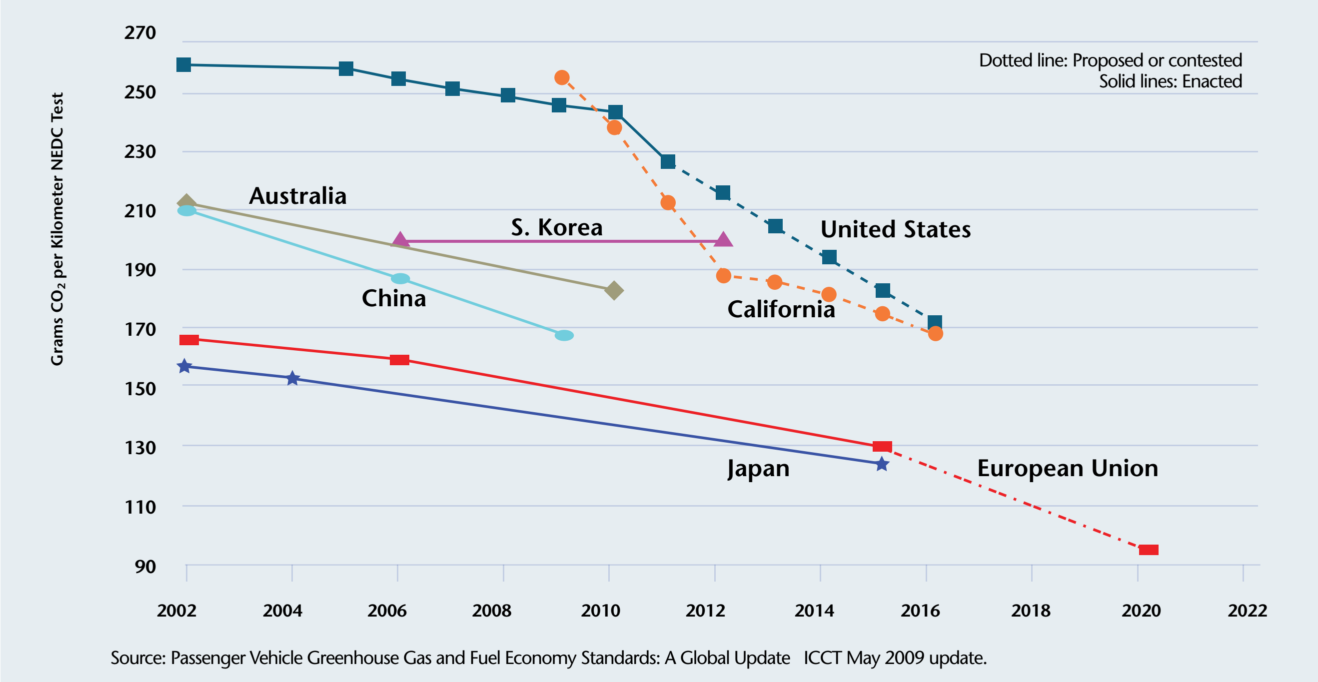
Fuel economy improvement is recognised as one of the key drivers for change in vehicle technology, and OEMs are increasingly looking to the lubricant to make a contribution. In this second feature in our fuel economy series, Jai Bansal, Infineum Global Crankcase Technology Advisor, examines the work being undertaken in this area by Infineum and specifically looks at how large a role lubricants can be expected to play in this quest for fuel economy improvement.

Fuel economy improvement, driven by the need to reduce greenhouse gas emissions and to reduce the operating cost of vehicles as fuel costs rise, is rapidly becoming a key driver for change for the transportation industry. Standards that limit CO_2 emissions have been in place for many years but, as they tighten the world over, the importance of improving fuel economy is gaining momentum. OEMs are looking at every element of the vehicle system for efficiency gains to help meet their emission targets in order to avoid significant financial penalties. In Europe for example, many OEMs will need to cut their CO_2 emissions by 10-30 g/km to meet the 2012 limits or face penalties for non-compliance, which could run to billions of Euros per annum.

OEMs are looking at a wide selection of new hardware technologies to cut engine CO_2 emissions. And unquestionably we expect that most of the improvements will come from these hardware modifications. However, engine lubricants will also have an important role to play in helping the OEMs to meet CO_2 emissions targets.

The question on OEMs' and lubricant marketers' minds is just how much of an impact can the engine lubricant have on fuel consumption – or perhaps, how large is the prize expected to be for those investing in fuel economy lubricants?

To better gauge the 'size of this prize', it is important to understand the distribution of energy losses over the different parts of the entire vehicle.



Fuel economy standards are tightening the world over

Energy in a vehicle is lost through a number of pathways, including heat, mechanical and drive train losses. Although estimates in the literature vary considerably, the broad consensus seems to suggest that approximately 16% of the energy loss can be attributed to mechanical losses. And more specifically that 5-8% of these mechanical losses can be attributed to engine internal friction.

Infineum studies

Many of the existing published papers on fuel economy lubricants are based on light-duty gasoline engines. Infineum was keen to conduct its own studies to see how universal these estimates were and to determine if the results could also be applied to diesel engines.

By using the industry-recognised Willans Line Method on a General Motors 6.5 litre diesel engine on a stationary dynamometer the mechanical losses were estimated at different engine speeds. In a separate experiment, the engine was operated at different combinations of speeds and loads to determine the relationship between the fuel energy input and the engine power output.

For high power output conditions, characterised by combination of high load and speed, or so-called 'line haul' operation, of the total fuel energy input 14% went to mechanical losses, 32% formed the useful work (brake horse power) and the remaining 54% was lost through thermal losses. The mechanical losses estimated from this work are closely aligned to the general consensus in the literature of 16%, making it reasonable to assume that these figures apply to a broad range of gasoline and diesel engines.

These results were obtained under line haul operation – however, in real life vehicles experience a variety of operating conditions and drive cycles. To mimic these, the Infineum experiments were repeated under a variety of operating modes. Whilst not a huge surprise, it is interesting that the mechanical losses as a percentage of the input energy vary a great deal with the power output of the engine – being at their highest when the engine is idle and is operating at its lowest efficiency.

As the engine load increases, more and more of the fuel energy goes towards the power output of the engine. Under these circumstances, the absolute magnitude of the mechanical losses may be higher than the idle operation but the magnitude relative to the total energy input is much smaller.

To estimate the 'size of the prize' that can be achieved with engine lubricants, it is important to understand that these mechanical losses are made up of three major components: air pumping, internal friction and accessories. Of these components, only the internal engine friction can be influenced by the engine lubricant. Since we do not have independent estimates of the internal friction from our study, let's assume that 40% of the mechanical losses are due to engine friction, a number that corresponds to the mid-point of the 5-8% frictional losses reported in the literature. This might be a controversial assumption but it is necessary in order to get a qualitative estimate of the potential impact of engine lubrication on energy savings.

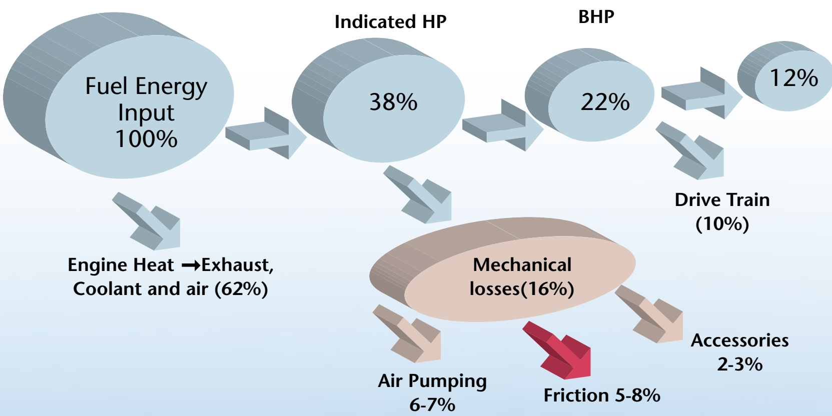
Using the total mechanical losses obtained in our study, the internal friction losses can be estimated as follows:

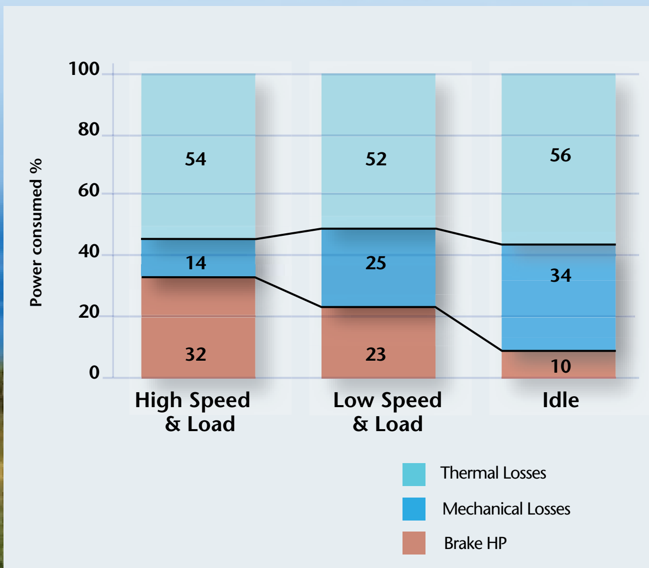
- High load/speed (line haul): ~ 6% (i.e., 40% of 14%).
- Low load/speed (typical of urban drive cycle): 10%.
- Idle: ~14%.

So, just how much of these losses can be recovered through smarter lubricant design?

The internal friction losses in the engine set an absolute upper limit on the amount of fuel efficiency that can be gained through engine lubricants.

Simplified energy balance in passenger vehicles





Mechanical losses vary greatly with power output

In reality there are several factors that limit the lubricant related fuel efficiency gains, including:

- No lubricant can be expected to completely eliminate internal engine friction.
- A lubricant will have its own internal frictional losses (i.e. viscosity).

A fuel economy lubricant attempts to gain the maximum reduction in engine friction whilst minimising its internal viscous losses. Literature data, consistent with our own studies, indicate that for line haul operation a well-designed fuel economy lubricant can offer fuel economy gains in the range of 2%, or roughly a 33% reduction of the engine friction losses. Applying this factor to different drive cycles, the fuel economy contribution from lubricants can be expected to be around 3% for low load/speed operation and 5% in idling mode.

From our research it is apparent that, the 'size of the prize' for fuel efficient lubricants is dependent on a number of variables, drive cycle being a critical one amongst these. Nevertheless a well-designed lubricant can make a very significant contribution towards fuel efficiency and towards meeting emerging CO_2 emissions standards. Infineum's scientists are making significant strides in finding ways to maximise the impact of lubricants in meeting these standards.

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