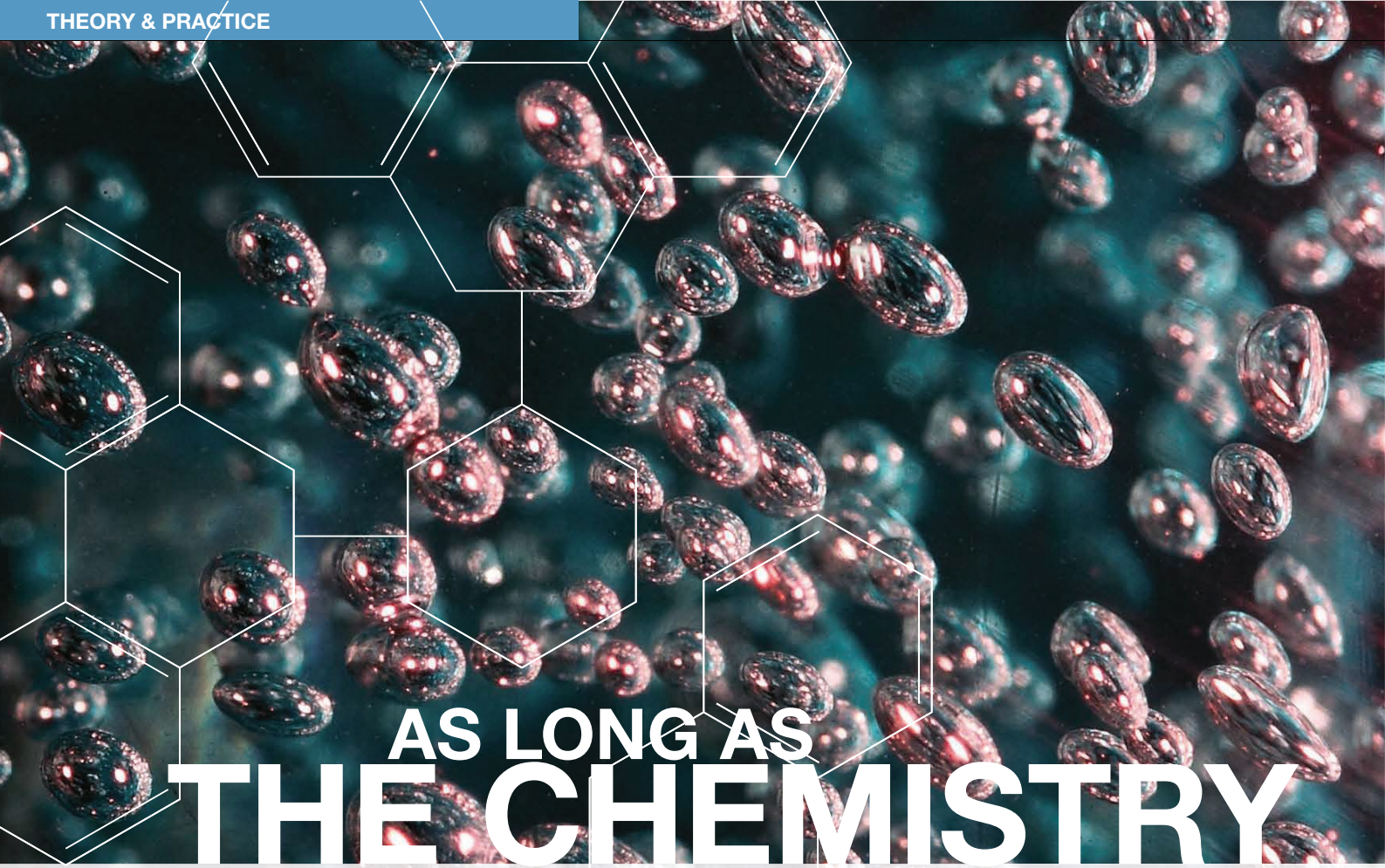
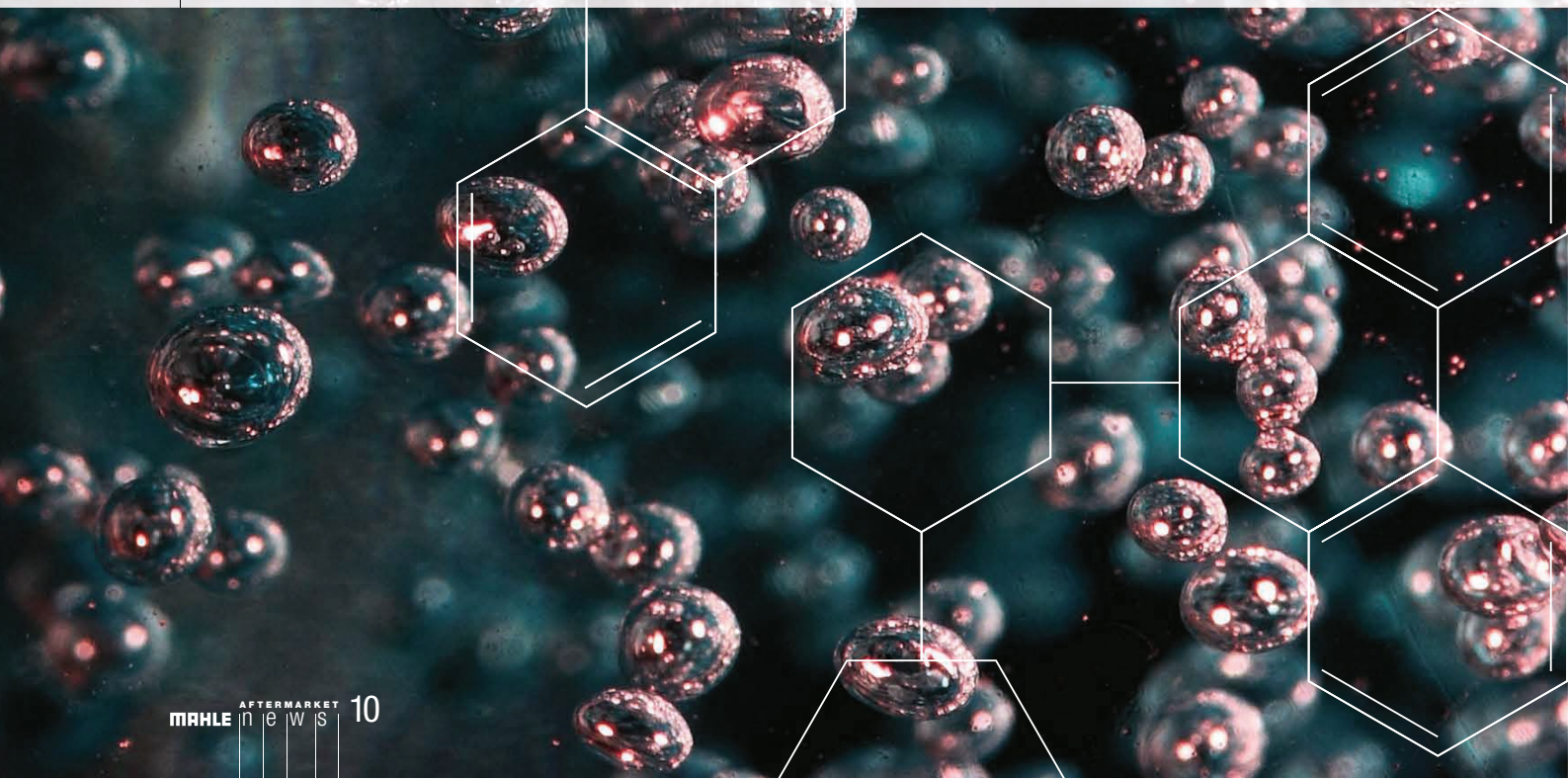


AS LONG AS THE CHEMISTRY IS RIGHT

MODERN ENGINES WITH STOP-START FUNCTION PLACE CONSIDERABLE DEMANDS ON THE BEARINGS: AS THE PROTECTIVE LAYER OF OIL IS NOT PRESENT WHEN STARTING, THE BEARINGS ARE COATED WITH POLYMERS.

In combustion engines, the main and rod bearings are hydrodynamically supported by the crankshafts. Hydrodynamic means: the oil pump forms a load-bearing, lubricating oil film in the small annular gap between the journal and the bearing. Due to the rotation of the crankshaft and the geometric design of the bearings, the oil film distributes itself evenly in the annular gap and supports the crankshaft. Despite the enormous cylinder pressures, and the static and dynamic forces acting on the crankshaft, the crankshaft "floats" in the bearings, without actually touching them. When surrounded with well filtered oil, the service life of the crankshaft and bearing is theoretically unlimited in this operating condition. The reality looks somewhat different as the protective lubricating film is not permanently available.



THE STARTING PROCESS: STRESS FOR THE ENGINE

When the engine is started, there is metallic contact between the main bearing journal and the lower bearing shell due to the crankshaft's static weight and—particularly on the flywheel side—the weight of the flywheel and clutch, or transducer. On the control side, the crankshaft is pulled upwards against the upper bearing shell due to the prestressing from the timing belt or timing chain.

The crankshaft starts to rotate during the starting process. The initial ignition sequences load the rod and main bearing, until the oil pump has formed an adequate, load-bearing lubricating oil film in the bearings. It is during this phase that so-called mixed friction occurs. Although there is oil residue in the bearings, this cannot prevent the metallic contact, which consequently leads to wear. However, the components have been designed and combined in such a way that wear is kept within limits over the engine's service life.

STOP-START FUNCTION: FUEL SAVING BUT WEAR-INTENSIVE

An ever increasing number of vehicles are equipped with a stop-start function: the engine is turned off every time the vehicle stops at a traffic light and re-starts when the accelerator is depressed again. The efficiency of this system speaks for itself—shutting off the combustion engine (even for only a few seconds) saves more fuel than restarting requires. This is a simple method for reducing fuel consumption.

In hybrid vehicles, the engine management system may even turn off the engine while the vehicle is in motion, should the operating conditions permit. This is always the case when the output from the electric motor and battery suffices for the actual driving conditions.

THE MAHLE SOLUTION: BEARINGS WITH UNIQUE POLYMER COATING

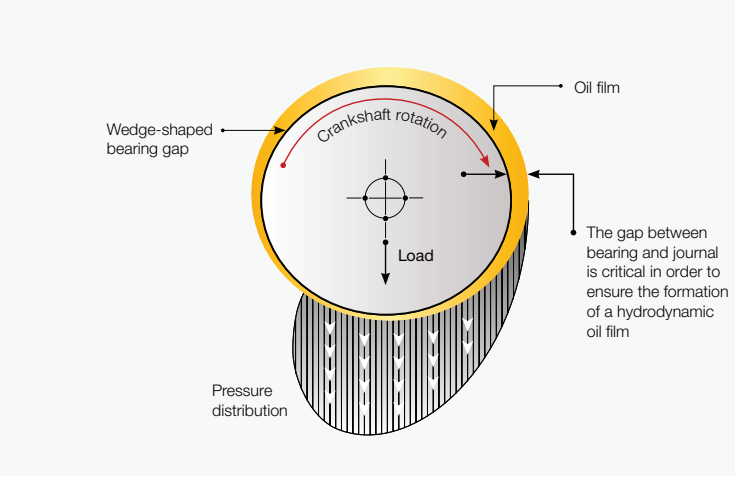
The innovative polymer coating is applied to standard aluminium two-component bearings or bronze bearings in several micro-thin layers—and at the end of the process, is only a few thousandths of a millimetre thick. The special feature: solid lubricants and aluminium flakes are embedded in the polymer matrix. Excellent tribological properties are achieved thanks to this special chemical compound. Mixed friction during the starting process no longer represents a problem for this coating technology—as it does not lead to any metallic contact with the crankshaft.

ALUMINIUM FLAKES FOR CONDUCTING HEAT, SOLID LUBRICANTS FOR REDUCING FRICTION

The aluminium flakes in the coating are good heat conductors and prevent a thermal overload in the bearings; the embedded solid lubricants considerably reduce friction in the critical lubricating conditions during the starting process and increase mechanical strength. In addition, the coating is extremely resistant to chemical stress. Consequently, improved wear and fatigue resistance has been achieved in comparison with established lead-based products.

POLYMER COATINGS: FUTURE-PROOF THANKS TO HIGH LOAD CAPACITY

The new polymer-coated bearings can be used directly in existing engines, but are also able to withstand the additional loads associated with future technology trends in commercial vehicle engines, such as stop-start systems.



Schematic diagram of the loads in a hydrodynamic bearing.

Various bearings with polymer coating.

Even when overrunning, the combustion engine is not in operation if the kinetic energy is being stored in the batteries as electric power. As a result of this distribution of power and associated frequent shutting off of the combustion engine, fuel savings in the region of 20–25% can be achieved, while considerably reducing CO_2 emissions.

The positive effect of turning off the engine, however, represents a challenge for the engine components, particularly for the bearings. The considerably more frequent engine starts push standard multi-component bearings to their load capacity. Ultimately, when the engine is shut off, the mechanically driven oil pump is at a standstill, the oil pressure drops, and the crank pins touch the bearings. Metallic contact will arise when restarting the engine, which increases the wear of the bearings.

Theoretically, an electric oil pump—as used in stationary engines—could provide assistance by building up sufficient oil pressure before the crankshaft starts to move. As such an oil pump has never been installed in passenger car or commercial vehicle series production to date, MAHLE has pursued a wholly new approach to resolve this problem—and developed "self-lubricating" bearings.

Nonetheless, the potential of the new polymer coatings is not yet exhausted: thanks to the excellent tribological properties, newly developed engine oils with reduced viscosity can be used—yet another important contribution towards reducing power loss due to friction and thus further minimising fuel consumption and emissions values.

Furthermore, the load capacity—considerably higher than conventional trimetallic bearings—opens the way for its use as an alternative to the high-strength sputter coating. MAHLE is currently carrying out practical tests to this end.

POLYMER-COATED BEARINGS FROM MAHLE—NOW AVAILABLE EX WORKS AS PART OF THE ORIGINAL EQUIPMENT

Since the beginning of 2013 MAHLE has been supplying the new polymer-coated bearings for series production—currently to renowned German, French, and American engine manufacturers. The interest in this innovation from other international manufacturers is significant and various development projects are on the brink of conclusion.