ATLAS - Active Thermal Layers in Automotive Systems

Integrated heat recovery for future hybrid and electric range extender vehicles

'ATLAS' is a joint industry-academia research project that aims to undertake systems analysis of a new integrated heat recovery concept for future hybrid and electric range extender passenger cars. The work is funded by InnovateUK under the IDP-13 Low Emission Vehicles Systems programme. The multidisciplinary work includes fundamental R&D of novel thermal swing coatings, quantification of ICE (internal combustion engine) performance effects, exhaust heat recovery analysis and electric motor and battery performance analysis. The project is led by Tata Technologies Ltd in collaboration with Jaguar Land Rover, Keronite International Ltd, TWI Ltd and the University of Nottingham. The one year project is expected to complete in June 2018.

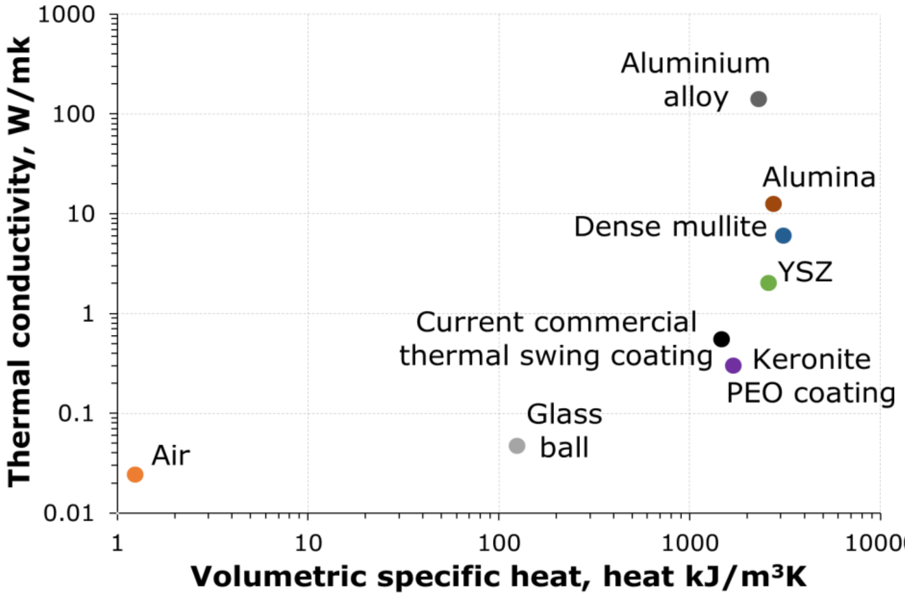

***Figure 1** Thermal conductivity of various materials and thermal swing coatings.*

An innovative approach for the project involves the development of a thermal swing coating that can reduce ICE wall heat losses by 30% using a novel plasma electrolytic oxidation (PEO) process developed and patented by Keronite Ltd. A thermal swing coating is different to traditional thermal barrier coatings (TBC) as the former not only has a low thermal conductivity 'λ' but also low specific heat capacity (Cv) as shown in **Figure 1**. Low 'λ' reduces heat transfer to the piston during the combustion stroke, while low 'Cv' reduces heat uptake and allows release back during the exhaust, intake and compression strokes. Such a combination allows the surface temperature to rise during the combustion period and decrease during the exhaust and intake strokes, reducing heat loss.

Keronite PEO is a plasma-assisted electrolytic process which is similar to anodising but conducted at significantly greater voltages. It is performed in an environmentally safe, low-concentration alkaline solution of proprietary composition. The process employs high electrical potentials so that discharges occur on the surface and the resulting plasma modifies the structure of the oxide layer, creating a coating of specific architecture and composition (**Figure 2**). The coating often has very high hardness, high adhesion, low stiffness, a continuous barrier and is capable of offering protection against wear, corrosion and heat.

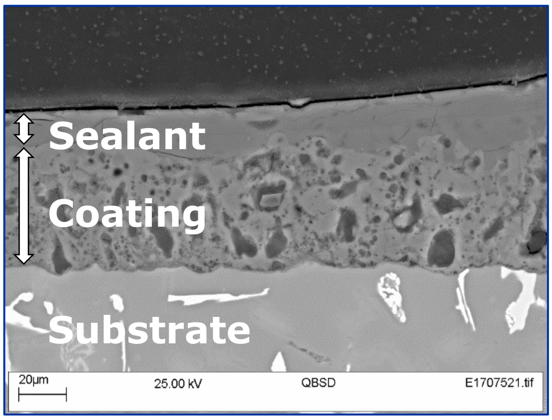

Figure 2 *A cross-section of the Keronite thermal swing coating.*

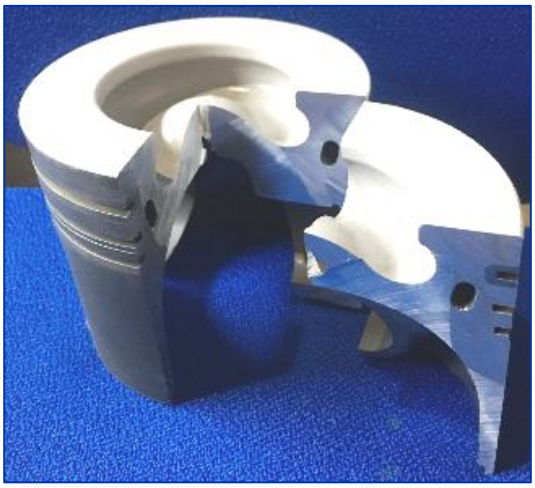

Figure 3 *A photograph showing a diesel piston (Al-Si alloy) coated with a Keronite thermal swing coating on the crown and bowl regions.*

The PEO technology has recently seen widespread use in aerospace, automotive, space, oil and gas, and general industry applications. One such application is for automotive pistons (**Figure 3**), where the coating can be designed to offer thermal swing effect. The approach is based upon creating a modified oxide layer on the piston surface by conversion of the surface as well as elemental co-deposition from the electrolytic constituents while entrapping air in a controlled pore-architecture.

Preliminary engine tests conducted by the University of Nottingham with a diesel piston coated with the Keronite PEO thermal swing layer have indicated an appreciable improvement in thermal efficiency and fuel consumption (**Figure 4**). Further tests to validate this improvement are currently underway. The project is due for completion in June 2018.

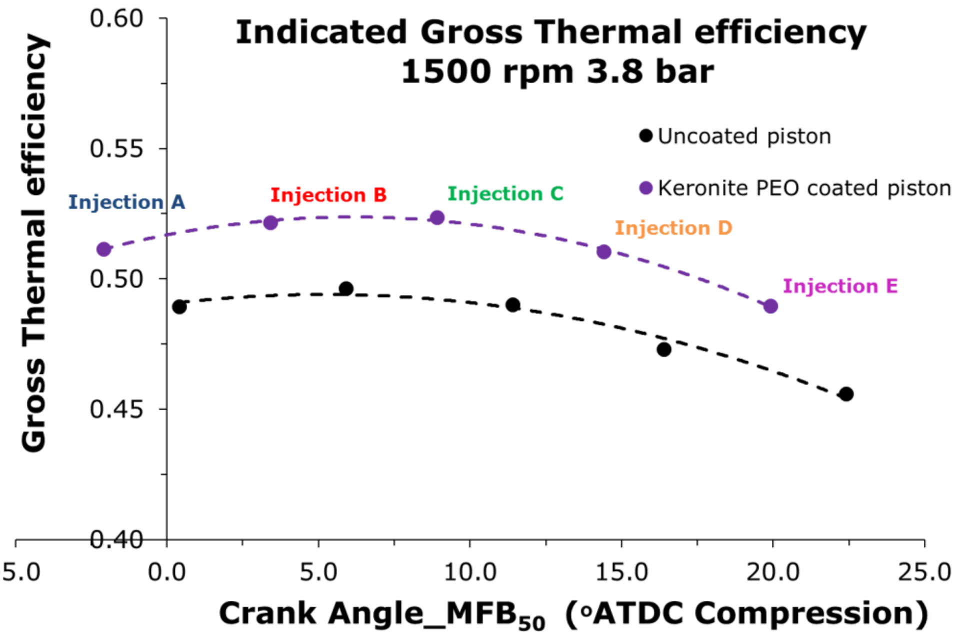

Figure 4 *Indicated thermal efficiency of the Keronite PEO coated vs uncoated piston from preliminary engine tests.*

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