The Development of the MAHLE 25kWe Solar Heated Stirling Engine

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Abstract

MAHLE International GmbH (MAHLE) is continuously investigating new products and technologies especially in the area of "low" or "zero carbon". MAHLE, together with its subsidiary, MAHLE Powertrain Ltd. (MPT), has investigated the concept of Stirling engines and in particular for solar power generation. Utilising significant experience within the automotive engine industry, MAHLE was able to produce a "clean sheet" 25kW engine design suitable for development into series production, and several fully functioning prototype engines for dynamometer testing.

This paper focuses on the development of the MAHLE Stirling engine. Beginning with simulations of both the thermodynamic and mechanical systems, and leading into the dynamometer testing of the prototype engines. Design details of the engine and overall concepts selected can be found in the sister paper ISEC2012-50 [1].

For the first time, a Stirling engine model was produced by MPT within the GTPower simulation package, allowing optimisation of all the major engine dimensions to achieve very high thermal efficiency. Due to the "clean sheet" design MPT was free to select many major aspects including cylinder bore & piston stroke, regenerator size and matrix detail, gas cooler and receiver / heater designs. It was also possible to model the thermodynamic effects due to small details such as gas control drillings and seal and valve leakage.

The mechanical aspects were optimised for high efficiency within the constraints of high service lifetime including base engine friction, oil and water pumps, bearing sizes, cooling system and engine & gas pressure control system.

The prototype engines were tested at MPT in Northampton, UK, using a bespoke natural gas burner, allowing the solar receiver to be retained. The MPT test facility was upgraded with high pressure (200bar) Hydrogen supply and associated safety systems.

Test results showed performance and efficiency to be very competitive with published data, achieving (shaft) power of 27kW and 38% efficiency at 1800rpm & 200bar peak working pressure. 25kW and 40.5% efficiency was achieved at the rated speed of 1500rpm.

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