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Design and Development of the Range Extender Engine

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ABSTRACT

The electric vehicle does not generate pollutants as it passes through inhabited areas, and can potentially rely on its energy being provided by a selection of renewable sources, making it the focus of much current interest. There is increasing interest in combining the desirable features of the electric vehicle with the range freedom of a conventionally fuelled vehicle, leading to the investigation of the extended-range electric vehicle (E-REV). The vehicle to be limited only by the combined capacity of the battery and a gasoline tank for the engine. A concept design was created and resulted in the final concept engine design specifications as summarised in Table 1.

Table 1 Summary of the MAHLE REx engine key technical specifications

Technical specifications	
Layout	In-line 2-cylinder, 4-stroke, gasoline
Engine displacement	0.9 litres
Bore / Stroke	83.0 / 83.0 mm
Compression ratio	10:1
Valvetrain	SOHC, 2 valve head, roller rocker arms
Fuel injection	Port fuel injection
Engine control	MAHLE flexible ECU
Generator	38 kW water-cooled permanent magnet axial flux generator
Maximum power	30 kW at 4000 rev/min
Peak torque	72 Nm between 2000 and 4000 rev/min
Emissions target	Euro 6
Dimensions	327 x 416 x 481 mm
Installation angle	Vertical or horizontal
Engine dry weight	50 kg (65 kg with generator)

The overall engine design is targeted at maintaining the lowest production cost to achieve the performance targets within the smallest possible package volume. The chosen solution uses a cast-in iron cylinder liner with an open-deck structure, as this method does allow for a close-coupled generator to be integrated into the engine structure and provides the lowest cost option for higher

volume series production. Given the low rated speed, and moderate specific power output requirements, the engine only requires 2 valves per cylinder. Similarly port fuel injection is employed for low cost, good NVH and best start-up emissions. One further feature of note is the ability of the engine to be installed at any angle from vertical to horizontal (exhaust side down) with only minor hardware changes. With an E-REV, the engine is not mechanically connected to the wheels of the vehicle and thus can be mounted anywhere within a vehicle. One significant consideration for the design of the cylinder-head coolant jacket was the ability to degas the jacket at any engine orientation between vertical and horizontal. A 180°-540° firing interval (0°-180° TDC firing angle) was chosen, as this configuration has no primary out of balance forces. The REx engine could experience a maximum acceleration under normal use of, say, 1 g in any lateral direction whilst the engine is not running. This would require the cam lobe to be fully enclosed to ensure retention of oil. As a consequence, standard roller followers were selected to overcome these issues in the REx engine.

The torque and power output of the engine met the performance targets, as can be seen in Figure 1, with peak power of 30 kW being achieved at 4000 rev/min.

It has been found that if the vehicle is charged nightly the CO_2 savings can be up to 100 % and that even if the E-REV is never recharged, the savings can still be as high as 50 %, given the right usage patterns.

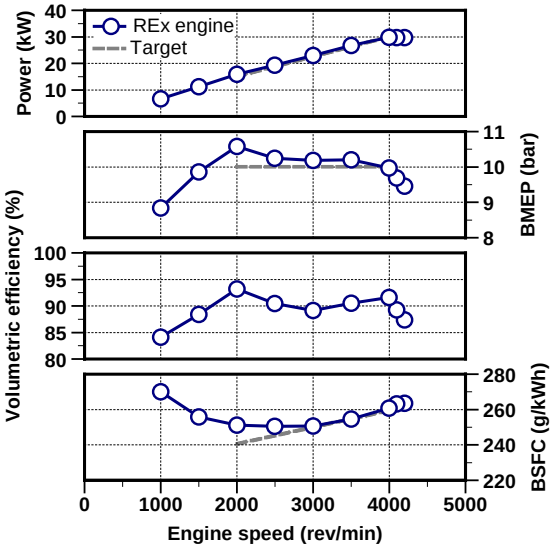

Figure 1 Tests results from the MAHLE range extender engine