VCR-VVA-high expansion ratio, a very effective way to Miller-Atkinson cycle

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ABSTRACT

Increasing the efficiency of internal combustion engines is mandatory to meet ever more stringent regulations. The implementation of very high compression ratio (> 18:1) is the key to take full advantage of the association of Variable Compression Ratio (VCR) and Variable Valve Actuation (VVA) in the implementation of Miller-Atkinson cycle, leading to higher thermodynamic efficiency and thus better fuel consumption benefits.

VVA systems allow differentiating geometric compression ratio and effective compression ratio. They theoretically permit to maximize expansion ratio (i.e. geometric compression ratio) while keeping an effective compression ratio in accordance with the constraints of the knocking limits, but with a limitation on the reachable maximum Brake Mean Effective Pressure (BMEP) at low compression ratio and the associated downsizing.

In order to optimize the genuine efficiency on real driving situation, the continuous adaptation of the geometric compression ratio of an engine in a large range [8:1; 18:1] is mandatory. The requirements of the VCR technology are firstly to ensure that the optimum Compression Ratio is set in only a few engine cycles for each operating points; and secondly, the technology must also guarantee a very precise altitude of the piston at Top Dead Center at very high compression ratio to operate safely.

A specific methodology is developed to determine the optimal compression ratio for each operating point when using VCR and VVA. It combines 0D simulations and Indicated Specific Fuel Consumption (ISFC) measurements on a single cylinder engine equipped with a high compression ratio combustion chamber. The resulting brake specific fuel consumption maps are used as input data in simulations to evaluate the impact of such a geometric compression ratio range, coupled with the use of Miller/Atkinson cycle, on the fuel consumption on standard cycles for given vehicles.

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