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Experimental Investigations of a DISI Engine in Transient Operation with Regard to Particle and Gaseous Engine-out Emissions

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ABSTRACT

The investigation of transient engine operation plays a key role of the future challenges for individual mobility in terms of real driving emissions (RDE). A fundamental investigation of the transient engine operation requires the simultaneous application of measurement technologies for an integrated study of mixture formation, combustion process and emission formation. The major prerequisite is the combustion cycle and crank angle resolved analysis of the process for at least several individual consecutive combustion cycles during transient operation.

The investigations are performed with a multi cylinder DISI engine at an Engine-in-the-Loop test bench, able to operate the engine in driving cycles as well as within target profiles (e.g. speed and torque profiles). The research project describes the methodology of analyzing elementary transient operational phases, (e.g. different variants of load steps). The aim is to visualize the detailed influences of engine parameters on individual consecutive combustion cycles during transient operation.

For the integrated analysis, several state of the art measurement technologies like fast response emission analyzers (HC, CO, CO_2 and NO) and fast particle emission analyzer (number and size distribution) are supplemented by the simultaneous use of optical diagnostic methods. For this reason a high-speed camera setup is used to visualize the fuel injection process as well as the resulting soot luminosity of the following combustion during transient operation. At the same time a special fiber optical spark plug is used to characterize the local lambda value at the spark plug as an indicator for the mixture homogenization and for the evaluation of the in-cylinder conditions prior to spark timing.

Keywords: Transient engine operation, load step, particle emissions, gaseous engine-out emissions, optical diagnostics, combustion chamber local lambda value, differential quotient of lambda value.

INTRODUCTION

No general terminology is provided to give a distinct definition of transient operation but several interpretations are used to deal with it.
One possible approach to classify the transient operation is to consider the temporal influences of engine parameters and their impact on the engine process. This is the basic approach for the classification described in Figure 1 [1]. This means that four different orders of transient operation are to be distinguished. The first transient order is the four-stroke engine process itself. Due to the fact of the open process control (gas exchange) and the cyclic irregularity, even the steady-state operation of an engine in this terminology is a transient process. The second order process describes all influences given by the request of engine's parameter changes requested by the driver. This exemplarily contains the demand for vehicle acceleration which induces a load-step of the internal combustion engine. Changes in engine speed due to gear shifting or deceleration are also elements of second order processes. Thus the second order is describing what is usually known as the transient processes of driving cycles.