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Optimal and Universal Calibration of a Heavy-Duty Diesel Engine and Aftertreatment System

The aim of this research project is the development of a so-called universal optimal calibration methodology for the engine control unit. The key idea is to calculate and store the multitude of all possible optimal emission-strategies and choose them freely depending on the engine model, application and environmental conditions. Thus, the calibration process is streamlined for the various engines and applications, thereby greatly reducing the development time and cost. Moreover, the method ensures that the maximum potential of the engine is used, thus minimizing the environmental impact. In a final step, the optimization is to be performed for the engine and aftertreatment system combined, which could reduce fuel consumption and pollutant emissions even further. The project is supported by Liebherr Machines Bulle SA.

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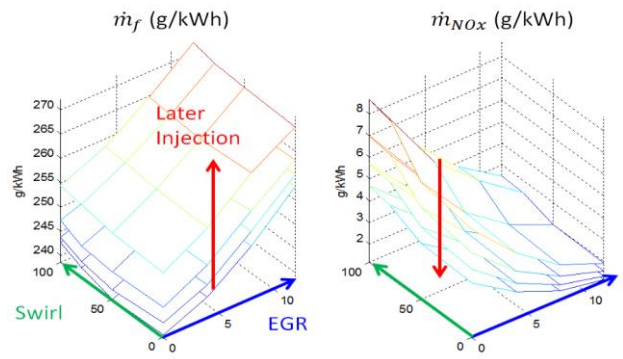
Introduction

Due to their high fuel efficiency, high torque output and good reliability, Diesel engines are widely used and particularly suited for heavy-duty applications. Liebherr Machines Bulle SA develops and produces high-quality diesel and gas engines for use in off-road applications, with various engine sizes, markets and operating conditions.

Universal Engine Calibration

Modern Diesel engines are subject to extremely tight requirements. Compliance with the statutory emission limits is technically very demanding and confronts engine manufacturers with numerous conflicting goals between fuel efficiency, pollutant emissions, manufacturing and development costs [1].

This project aims at developing a systematic, measurements-based method to optimize the reference values for the feedforward and feedback controllers of the in-engine actuators. In contrast to common methods, the multitude of all possible optimal emission-strategies is calculated and stored in multidimensional look-up tables. This so-called universal optimal calibration of the engine control unit allows changing the emission-strategy instantaneously during operation.

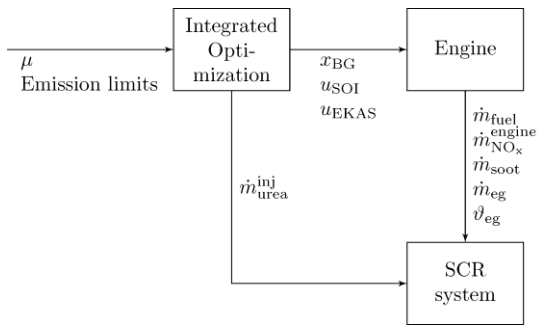


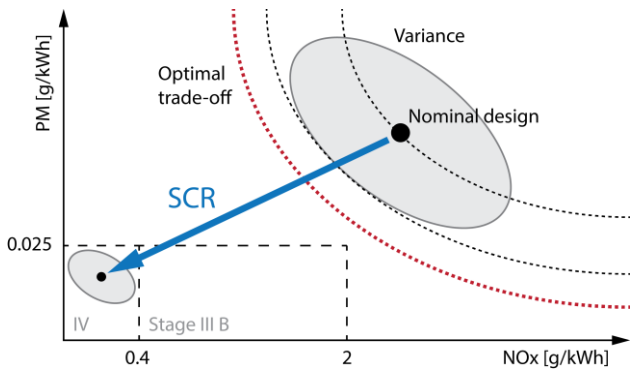
Thus, this methodology ensures that the maximum potential of the engine is used, since each strategy lies on the optimal trade-off curve. Furthermore, it offers great flexibility in the development process, because the calibration is streamlined for the various engines. Finally, the ultimate choice of the emission-strategy is easily adapted to the environmental conditions of the application.

Combined Aftertreatment Optimization

In order to achieve the latest and future emission legislation limits, while retaining the highest possible efficiency, the use of an exhaust aftertreatment system is crucial. Selective Catalytic Reduction (SCR) is the leading and most promising technology to clean the exhaust gas from mono-nitrogen oxides (NOx) [2].

The exhaust aftertreatment system is usually optimized separately from the engine. In this project, however, the combined system is considered, taking into account the interactions between raw emissions of the Diesel engine and chemical processes inside the SCR system. This has the potential to reduce both Diesel and AdBlue consumption, or to decrease the size of the SCR catalyst.





Expected Impact

The development and use of the so-called universal optimal calibration methodology, and the combined optimization of diesel engine and exhaust gas aftertreatment system, ensure that the available resources (e.g. Diesel fuel and time for development) are fully utilized and that the environmental impact (caused by pollutant and carbon-dioxide emissions) is minimized. For Liebherr Machines Bulle SA the results of this research mean a higher productivity, since the calibration process can be streamlined for the various engines and applications, as well as increased competiveness, because their engines will be cleaner and more efficient.

References

[1] P. Elbert, C. Barro, A. Amstutz, C. Onder and K. Boulouchos, Emissionsoptimierter Dieselmotor, Informationstagung Motoren R572, Pages 4-45, Frankfurt, 2015.

[2] M. Wang, Model-Based Control of Selective Catalytic Reduction Systems, PhD Thesis No. 22829, ETH Zurich, 2015.

Partners

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