SUCCESS STORY

LEC HybTec
Hybrid Technologies for Enhanced Reliability of Ultra High-performance Engines.

Programme: COMET – Competence Centers for Excellent Technologies

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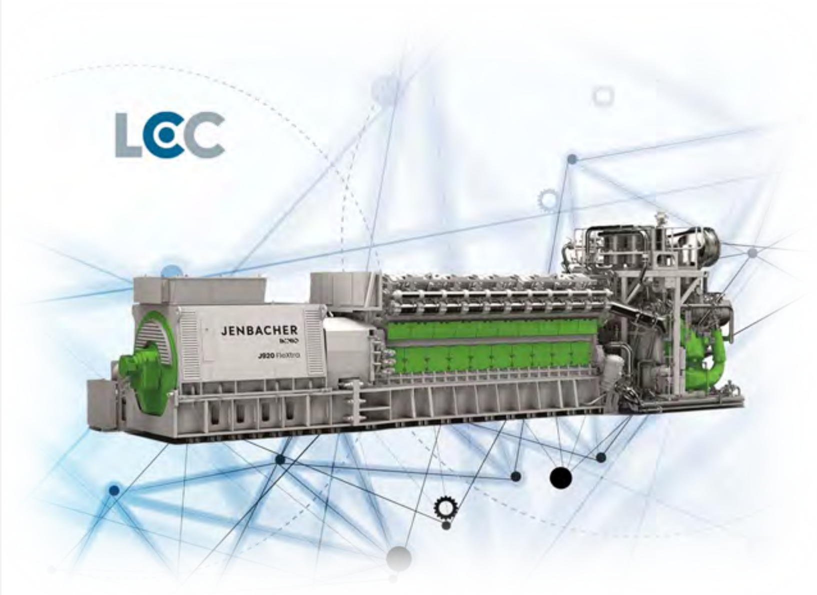

DATA-DRIVEN KNOCK PREDICTION METHOD

THE USE OF DATA-DRIVEN METHODS TO DETERMINE THE KNOCK TENDENCY OF ENGINES ENABLES THE TRANSFORMATION TO SUSTAINABLE HIGH-PERFORMANCE ENERGY SYSTEMS AND RENEWABLE FUELS.

The transformation from conventional to renewable fuels poses major challenges for developers of engine-powered energy systems. Increasing efficiency and, in the case of conventional fuels, reducing CO_2 emissions also remain important aspects. To achieve these goals, extreme operating strategies close to the engine's stability limit are necessary, yet they may result in undesirable knocking combustion. To ensure stable engine operation without running into engine-damaging knocking combustion, it is imperative to predict the knock tendency as a function of the respective engine operating parameters. Experimental investigations on single-cylinder engine test beds play a critical role as a number of operating conditions can be analyzed under controlled boundary conditions. Since experimental resources are limited, especially for large engines, a well-structured approach to efficient prediction of the knock tendency is required. Data-driven methods offer great potential here and can be effectively utilized with the developed method.

Innovative knock prediction method

The method developed by LEC HybTec enables prediction of the knock probability of an engine operating point. The aim was to derive a data-driven regression model from a limited number of engine test bed measurements that describes the empirical knock probability as a function of relevant engine operating parameters such as excess air ratio, ignition timing or boost pressure. The data set necessary for training the model is generated based on a Design-of-Experiments approach. To reduce the experimental

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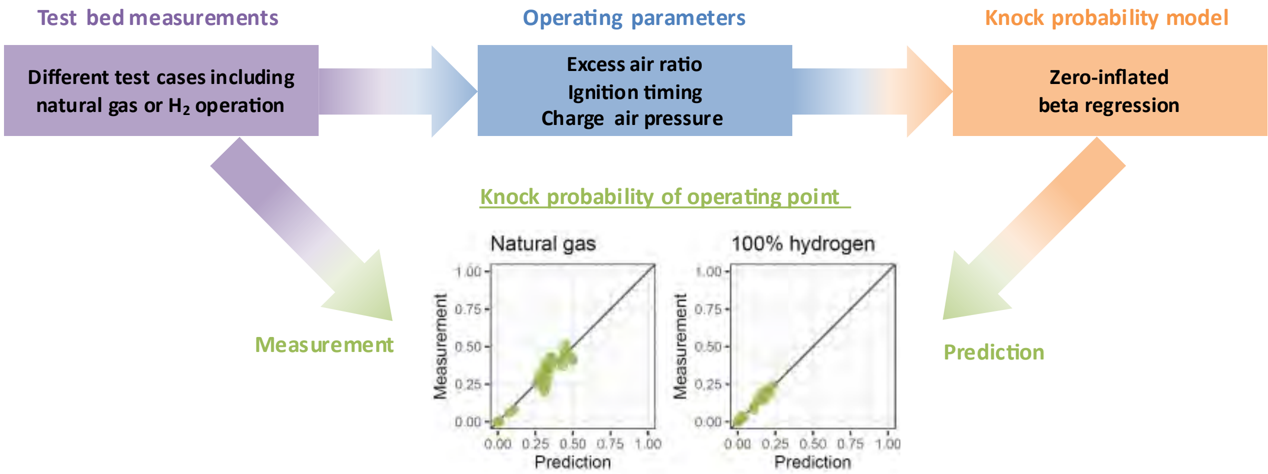
effort required to create the model, correlations between the engine operating parameters were considered during the creation of the test plan, which made it possible to reduce the number of measured operating points. The regression model depends crucially on the underlying distribution assumption for the correlation of the knock probability with the relevant control and operating parameters. On the one hand, a suitable distribution must be able to model the knocking operating points as accurately as possible; on the other hand, its accuracy must not be negatively influenced by the disproportionately large share of non-knocking operating points in the data sets. A zero-inflated beta regression proved to be ideal for the empirical knock probability model. The validation of the proposed method also yielded excellent results in hydrogen operation for various test cases with real large engines.

Use of the method for sustainable applications in the large engine sector

This method enables the prediction of engine knock tendency with a reduced number of engine test bed measurements. As a result, cost-intensive experiments can be avoided. The proven high prediction accuracy permits engine operation close to the knock limit in practice, which offers great potential for reducing CO_2 emissions. The successful application of the model in hydrogen operation brings developers one step closer to carbon-free engine technologies.



Method for predicting knock tendency – Copyright © LEC GmbH

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