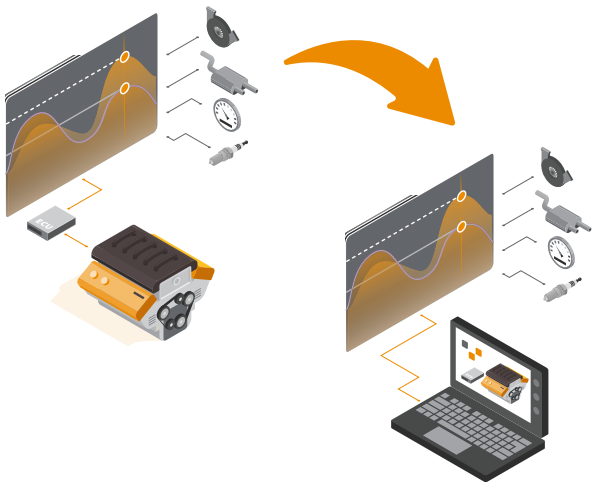
VIRTUAL ENGINE CHARACTERISTICS
TO OPTIMIZE THE TEST PROCESS

TASK

Modern combustion engines are centrally controlled by engine control units. Setpoint maps are applied on these units (with the help of models) for various adjustable parameters of the engine, such as injection start and duration, rpm, exhaust gas recirculation rate, load or boost pressure. For this purpose, operating points are defined to determine the necessary characteristic values, e.g., for emissions, torque, exhaust gas temperature or specific fuel consumption.



Here, the optimum combination of parameters at the respective operating point is decisive for the creation of exact characteristic curves across the engine‘s operating range. Typically, these characteristic curves are measured on the real engine in the laboratory. However, if, for example, temperatures are to be determined for different speed, pressure, and time variations, it quickly becomes necessary to measure over 500 operating points. This makes a map calculation on the real machine very complex, time-consuming and, at the same time, error-prone. The aim is therefore to simulate and to automate this process using the test automation software ECU-TEST, among other things, to not only save time, but also to eliminate the need for cost-intensive prototypes.

SOLUTION

First, an existing engine model is administrated to a simulation tool via ECU-TEST. The simulation tool (e.g., Silver) then calculates the characteristic values at the operating points for the multiple combined application parameters, and simultaneously returns the output signal values of the virtual engine. The average signal values are then written to a table with the other variables. This characteristics table can then be processed further in a customer-specific tool (e.g., MATLAB).

An automated calculation of these characteristics tables is performed for each operating point on the basis of parameterized test cases. For this purpose, an abstract test case is created in ECU-TEST beforehand, which

automatically arrives at and calculates an operating point. The signals to be recorded are also defined, and signal calculations are performed.

ECU-TEST provides a parameter set generator so that the pairs of characteristic values do not have to be entered manually when parameterizing the test case. This automatically reads out the characteristic value pairs/ application parameters from a value table (e.g., Excel) for each operating point and generates a parameter set from them. These are stored in a directory together with the logical test cases, and can then be executed in ECU-TEST.

ECU-TEST simulates the parameterized test case via the associated simulation model and calculates an average signal value for the characteristic values at the special operating point. This value is then written to both a test report and to the characteristics table. Gradually, all test cases for each operating point are run through fully automatically. Before ECU-TEST, this was only partially automated.

On the basis of this initial automation, the entire map can be calculated in about half the time, compared to the real test bench time.

But it can be sped up even more: by exploiting additional potential through distributed parallel execution of tests – with our test management tool TEST-GUIDE. The procedure is realigned for this purpose. Firstly, all characteristic values are read from the value table and then concrete test cases are automatically created, i.e., a test case with a concrete parameter set. These concrete test cases, or packages, are transferred to TEST-GUIDE and saved. TEST-GUIDE then independently organizes the test execution of the packages by means of integrated monitoring of the available test bench resources. If resources are available, TEST-GUIDE distributes the packages to them. Both the test execution and the calculation of the characteristic values are then performed with ECU-TEST. All map calculation results are written to a table. A test report is then automatically generated and returned to TEST-GUIDE, which further accelerates the process.

RESULT

With parallelized test executions via TEST-GUIDE and the downstream comprehensive evaluation, the entire map can be measured in less than 6 hours, compared to over 24 hours using the conventional method. This has also created a basis that enables resources to be scaled depending on the test volume. Another major advantage during the entire process is the continuous traceability of the test execution – from the test progress to the results review.

In the end, it turns out that integrating TEST-GUIDE into existing processes is not only uncomplicated, but it also offers extremely high added value in the test workflow. ECU-TEST and TEST-GUIDE are part of the TraceTronic Automotive DevOps Platform.