How MAN Controls Emissions with TargetLink

- 80% of the code done by TargetLink
- Flexibility and openness are the key factors of TargetLink
- TargetLink´s generated code comes close to handcoded quality

Increasingly stringent vehicle exhaust laws require increasingly powerful exhaust treatment technologies. In diesel engines, the main emissions are soot particles and nitrogen oxide (NO_x), which can be significantly reduced by additional exhaust treatment systems. MAN Nutzfahrzeuge AG has developed a controlled continuously regenerating trap (CCRT) system that can cut particle emissions by up to 90%. To develop the CCRT system, we successfully used TargetLink, the production code generation software from dSPACE.

The Idea Is to Oxidize the Soot

Filtering soot particles is itself not a great problem in the field of exhaust treatment. The real technical challenge is to regenerate a filter when it is clogged with soot, in other words, to burn off the soot so that it does not adhere permanently. There are a number of methods available for filter regeneration. For example, automatic regeneration while the vehicle is in motion can be achieved by means of a diesel-fueled burner. Another option is filter regeneration using the CCRT system.

A Chemical Reaction with a Remarkable Effect

The CCRT system is currently one of the approaches being used to find a quick solution to the problem of harmful particle emissions. The CCRT system combines the effect of the particulate filter with that

MAN busses and coaches with state-of-the-art exhaust technology.

of the oxidation catalyst. Using the system, soot is combusted (oxidized) as follows:

A preceding oxidation catalyst turns nitrogen monoxide (NO) into nitrogen dioxide (NO_2) by adding oxygen (O). In the particulate filter, the nitrogen dioxide (NO_2) combusts with soot (C) to form carbon dioxide (CO_2).

Reaction equation:

Oxidation catalyst: $2NO + O_2 \rightarrow 2NO_2$

Particulate filter: $C + 2NO_2 \rightarrow CO_2 + 2NO$

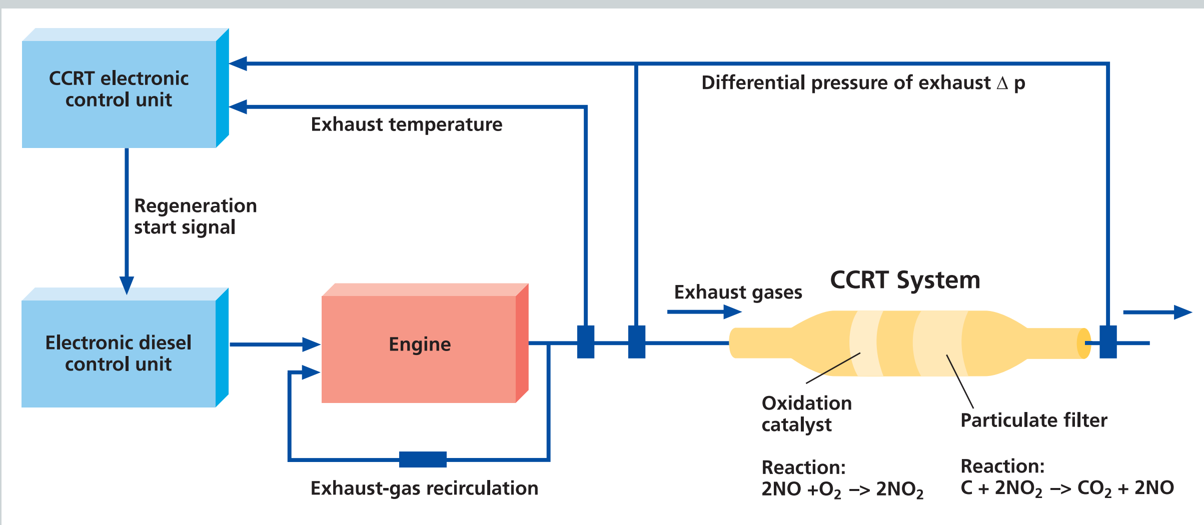
However, this reaction can only occur at specific operating states. The temperature and quantity of the present NO_x molecules play a decisive role in oxidizing the soot.

The CCRT ECU Intervenes to Prevent Clogging

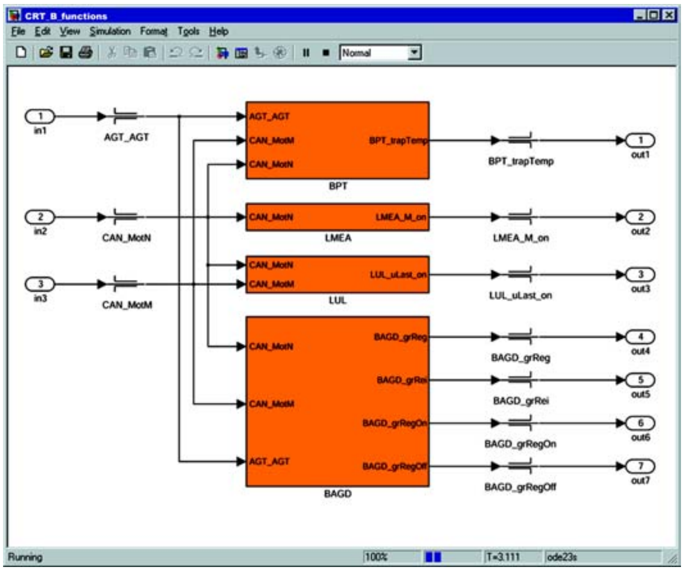
The CCRT electronic control unit (ECU), which regulates the reaction, monitors the quantity of soot in the particulate filter by means of the differential pressure at the two outputs of the CCRT system. When clogging is imminent, the ECU sends a start signal to the engine ECU, which then brings about the temporary operating state (for example, an increase in exhaust temperature) that is required for the regeneration of the particulate filter. The CCRT

CCRT system: ceramic surface of the particulate filter.

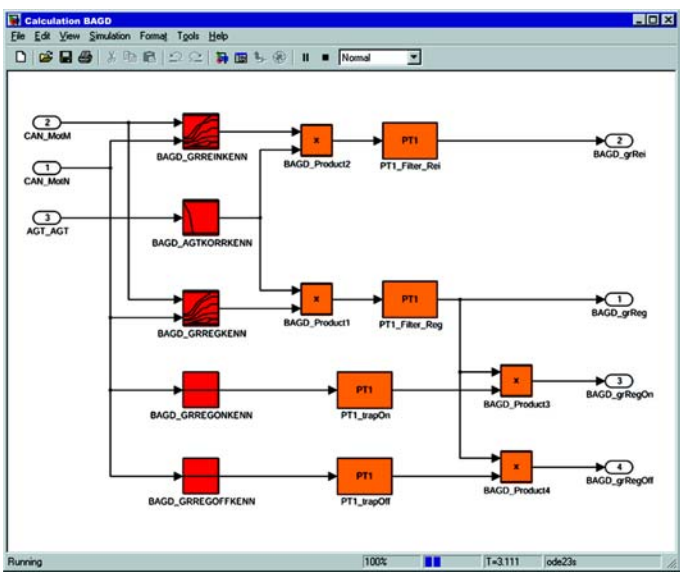
CCRT System Control



The CCRT ECU has sensors that measure the raw exhaust temperature and the exhaust pressure differential, which is an indication of the quantity of soot particles in the particulate filter. If the exhaust pressure differential rises above a certain limit, the CCRT ECU initiates regeneration of the particulate filter by prompting the engine ECU to bring about the necessary operating state. This is achieved by a temporary increase in exhaust temperature, among other methods. At this operating state, the soot combusts to form CO_2, and the exhaust pressure differential drops continuously as soot is burned off the filter. When a lower limit is reached, the CCRT ECU prompts the engine ECU to return to the normal operating state.



Module structure for CCRT model computation.



Function for computing exhaust pressure differentials.

ECU was implemented on the basis of a C167 processor platform. In addition, a task-oriented operating system developed by MAN was used.

As only around 20% of the function specification was known at the start of the project, it was important to simulate the functions, especially the new ones, in advance, and be able to include them in the ECU quickly using the code generated by TargetLink.

TargetLink Produced 80% of the Code

A point to note is that apart from pure hardware-related software components such as drivers, logs, etc., all the software functions including the diagnostic functions were generated by TargetLink. This is around 80% of the total code volume of the application, which was 82 kilobyte.

This high proportion of TargetLink code was achieved by systematically utilizing TargetLink's functionalities and MAN's own TargetLink function libraries.

Flexibility and Openness are Key Factors

TargetLink was the ideal solution for us, as the generated code came close to handcoded quality in the quasi-continuous function components. Moreover, TargetLink had already been used successfully in several in-house projects. Because it uses MATLAB®/Simulink® as a platform, TargetLink is very flexible and open. The system can be adapted to requirements, and if necessary extended, at any time. We prefer this approach to systems that impose rigid structures for modeling and code generation.

Another important point is the ability to use TargetLink to generate standard application files that comply with the ASAM-MCD 2MC standard, so that the ECU can be calibrated by a standard application tool.

Finally, we would like to praise the dSPACE support service, which responded with exemplary speed and high quality throughout the project.

Another Application in the Pipeline

This positive experience has convinced us to continue relying on TargetLink. We will therefore be expanding the field of automatic production code generation.

The next ECU for another application is already being planned. It will be implemented with the support of TargetLink and an operating system compliant with the OSEK/VDX standard. Its complexity will be similar to that of an engine ECU.

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