Hangover for catalytic converters

A long-term road trial with six cars revealed that the admixture of (bio-)ethanol to gasoline makes the catalytic converter age faster. The catalytic converter of a gasoline-driven car retrofitted for biogas didn't even last 40,000 kilometers. Overall, the catalytic converters did, however, prove to be surprisingly robust in the practical trial.

TEXT: Rainer Klose / PICTURES: Empa

Test bench measurements after 10,000 km: project leader Potis Dimopoulos Eggenschwiler (right) discusses the damage-pattern inside of the catalyst with technician Mathias Huber.

Without the famous 3-way catalytic converter our air would be far more polluted. That's why Empa took a very close look at this component in a long-term study. The question was: what happens to the sensitive precious metal coating in the course of 40,000 kilometers of normal driving? The catalytic converter not only comes into contact with the combustion gases, which it breaks down chemically and then releases as harmless substances into the environment. Fuel, engine oil and even the engine itself release substances into the exhaust gas, which can "poison" the surface of the catalytic converter: sulfur, phosphorous, calcium, magnesium and zinc stem from burnt engine oil, iron from the mechanical wear and tear of the engine. So how much "toxin" must a catalytic converter be able to bear and when does its efficiency start to suffer? And: do bioethanol and natural gas/biogas place an additional burden on the catalytic converter?

In order to compare various fuel options, the researchers chose as the test subject a widely used mid-range car officially approved by the manufacturer for both gasoline and bioethanol (E5-E85). What's more, in Switzerland this vehicle is also available in a version retrofitted for natural gas. Four of these vehicles were equipped with a catalytic converter and each driven more than 40,000 kilometers in normal traffic. One of the vehicles was powered with pure gasoline (E0), one with gasoline with a 5% ethanol admixture, like the mixture sold at gas stations as Super95. One car was powered with E85 – a mixture of 85% ethanol and 15% gasoline. The fourth vehicle ran on natural gas from the Swiss grid. After every 10,000 kilometers exhaust gas behavior was examined on Empa's motor lab.

In order to also measure the impact of engine oil on catalytic converter aging, two other natural gas vehicles from a different manufacturer were included. One was driven the 40,000 kilometers on normal long-life oil in line with the manufacturer's recommendations. The engine of the second vehicle was filled with a special low-SAPS oil developed for diesel vehicles with a particle filter containing less sulfur and phosphorus (which should protect the catalytic converter). Three Swiss oil producers and the manufacturer of the catalytic converter participated as industrial partners in the project.

The result: eco-fuel clogs up catalytic converters

After 40,000 kilometers the research team took the catalytic converters apart and examined their surfaces using an electron microscope and the deposits using X-ray spectroscopy. The pure gasoline option had done the least damage to the catalytic converter and left behind the least harmful deposits. But already the admixture of 5% bioethanol led to visible changes in the surface of the catalytic converter: the active layer, called the washcoat, was eroded much more. Also, more ash was observed on the surface of the catalytic converter, which partially covered the active layer. The same effects were even more obvious in the case of the vehicle run on E85. At the entrance to the catalytic converter not only the top but also the underlying washcoat layer was partially eroded. In addition, there were compact ash layers on the damaged surface.

The examinations of the converted natural gas vehicle had to be abandoned because the engine control was so unreliable that the catalytic converter already burnt out during the test phase due to overheating. There were holes in the honeycomb structure. The situation was different in the case of the two factory natural gas vehicles: their catalytic converters showed similarly good performance to the catalytic converter of the gasoline-driven vehicle. The researchers merely noted minor ash deposits that could be attributed to the special engine oil. Project leader Potis Dimopoulos Eggenschwiler: "The more oil an engine consumes, the more phosphorus, calcium, magnesium and zinc we found on the surface of the catalytic converter – albeit in amounts that scarcely impact its performance. Bioethanol, by contrast, attacks the active catalytic converter layer directly." The overall damage during the long-term trial was, however, only minor; but the causes will have to be explored in further studies according to the Empa scientist.

"Long" catalytic converters help

The good news is that the exhaust gas emissions scarcely worsened despite the partially visible damage to the test converters. The reason: damaged washcoat layers and ash deposits were observed above all at the front end of the catalytic converters – where the exhaust gas is the hottest and its passage through the honeycomb structure the most turbulent. Further back all the catalytic converters were intact and could maintain their cleansing performance. The manufacturers are aware of this and they are, therefore, integrating longer catalytic converters than required by the type test. This is the only way of complying with the stiff durability requirements of exhaust gas legislation, which specify that a catalytic converter must last for at least 160,000 kilometers. //