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Research on ammonia emissions in gasoline passenger cars with three-way catalysts

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Reducing emissions from internal combustion engines is being worked to clean the atmosphere of the future. On the other hand, it has been becoming tightened exhaust emission standard from vehicle and also Ammonia (NH_3) is featured as forming particulate matter (PM) in the atmosphere recently. Purpose of this study is to be clarified as key parameters to emit NH_3 on actual vehicle, and it was done and analyzed actual vehicle test for some driving cycle, ambient temperature, and catalyst deterioration. And it was also compared conventional powertrain with hybrid electrical vehicle. This paper shows these results of tests and analysis and key parameters identified to NH_3 emissionTo clarify key parameters for actual vehicle to make emit NH_3, following process was conducted. First, to confirm location where NH_3 generate, it was conducted measurement NH_3 at outlet of engine, CC(manifold) catalyst, and tailpipe. From this result, it was clarified that NH_3 is no or less generated at engine outlet and mainly generated at catalyst.

Next, it was conducted calculation with simulation model with several chemical reaction equations to clarify generating mechanism in catalyst. It was confirmed that NH_3 is not emitted in condition oxygen is supplied or existed enough, and it occurs both generating and oxidizing reaction in catalyst with rich gas condition at inlet of catalyst. So emitted NH_3 is also suppressed in case of keeping oxidizing reaction environment. As a result, it is clear to be significant to manage oxygen in catalyst.

Based on simulation result, it was conducted vehicle test with some parameter or condition change mentioning below. To clarify catalyst deterioration is affected to generating and oxidizing reaction, it was conducted vehicle test at ambient temperature in 23 degree C and -7 degree C on WLTC test and compared among green catalyst, catalyst after around 40,000 km driving, and after around 200,000 km driving. It was not clear tendency of NH_3 emission against catalyst deterioration in whole cycle, and the similar result at both temperature condition. As it can be seen from this Fig.1. it shows different characteristic between during warming-up and after warming-up condition. It shows increase NH_3 emission for deterioration after warmed-up condition. It can be considered that this result was caused by changed or reduced oxygen storage capacity and velocity of absorption and desorption on catalyst, which is one of effect of oxygen storage to emitting NH_3 with clarified with calculation with simulation model.

To be clarified clearer characteristics, it was conducted vehicle test on different environmental temperature condition which was able to consider one of parameter to be effect to NH_3 emission. Test condition to measure NH_3 emission were with vehicle with catalyst of after 200,000km driving and conducted with ambient temperature as -7, 0, 14, 23, and 35 degree C on WLTC. The result is shown in Fig.2 as ratio for result of 23 degree. Result with catalyst in green and catalyst in after 40,000km driving is also shown in the same figure, which is on -7 and 23 degree C. It is clear that lower temperature condition became higher NH_3 emitted and it is also found that even different deterioration of catalyst has similar sensitivity towards ambient temperature.

NH_3 has to be the same on even different driving pattern.To confirm this assumption, vehicle tests were conducted on even FTP and CLTC. Most NH_3 emission was measured during early phase until around 1000 sec on each driving cycle. However, to be focused on 500 sec from start, CLTC had different tendency from WLTC and FTP. As air-fuel ratio and temperature of CC catalyst were the similar among each cycle, it is considered that melting and vaporing against generated NH_3 to condensed water in exhaust pipe, were occurred more on CLTC than on other cycles. Therefore , it is necessary to investigate effect of this phenomenon more.

As result of comparison between conventional powertrain and hybrid electrical vehicle(HEV), relatively large difference and lower for NH_3 emission was found on early phase, which was warming-up phase. It is considered in order HEV has flexibility against engine operation and has characteristic to keep easier to optimized condition like air-fuel ratio or oxygen storage management for three-way catalyst than vehicle with conventional powertrain, and had effect strongly on early phase especially.

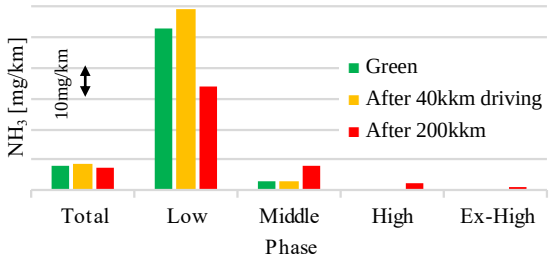

Fig.1 Catalyst deterioration effect for each phase on WLTC with cold start condition

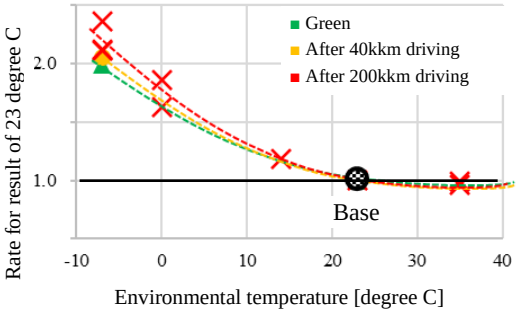

Fig.2 Result of effect for environmental temperature.