Pareto Front Based Design of Controllers for the Automotive SCR Catalyst

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Abstract
Diesel engine exhaust gases contain amongst other things nitrous gases such as NO and NO_2 (together abbreviated NOx). Reducing the amount of these gases is of great importance due to new legislation, and because of their effect on urban air quality [1]. A promising and widely used technology for this is based on selective catalytic reduction (SCR) of the gases, with ammonia (hydrolyzed Urea) as a reducing agent [2, 3]. Challenges with this technology include dosing the right amount of urea to reach maximum NOx conversion, while simultaneously keeping NH_3 slip below legislation. This requires efficient dosing algorithms, and to this end, model based control is a promising strategy. Due to the fundamental properties of the SCR catalyst, selection of a controller is often a trade-off between NOx slip and NH_3 slip, and because of this, getting an objective function that describes the required properties of a controller can be difficult and time consuming. Using pareto fronts to graphically analyse the best possible trade-off between NOx slip and NH_3 slip for different control structures can help towards developing an objective function that well describes current legislation.

A previously developed high-fidelity model [4, 5] has been used to simulate a broad variety of control structures. In Figure 1, pareto fronts can be seen where the simulated controller is a proportional feedback controller with different amounts of pre-dosed ammonia based on the inlet NOx measurement. ANF = 1 corresponds to the case where the same amount of NH_3 is pre-dosed as there is NOx in the inlet. Based on the control structure, it is possible to shift the pareto front in the desired direction. These results will be used to develop an objective function that well describes the desired trade-off between NOx slip and NH_3 slip.

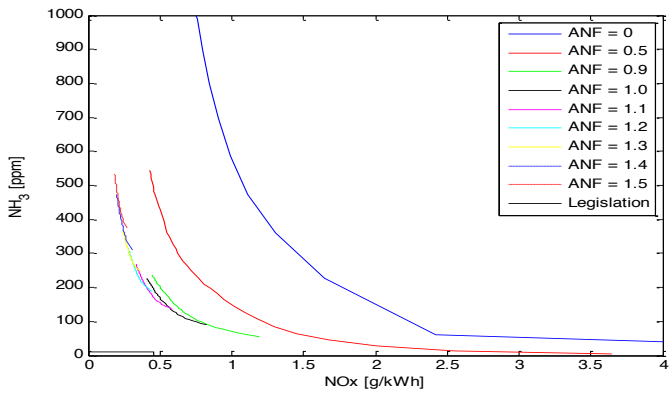

Figure 1. Pareto fronts for P controllers with varying feed forward controllers based on Ammonia to NOx ratios (ANF).

References
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