251g Periodic Nox Storage and Reduction (Nsr) for Lean Burn Engines

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Lean-burn gasoline and diesel vehicles have higher fuel efficiency than conventional gasoline vehicles, but produce more NOx and in a net oxidizing exhaust which makes the traditional TWC ineffective for NOx treatment. One of the emerging techniques for NOx reduction is that of NOx Storage and Reduction (NSR), and the device in which NSR is carried out is commonly referred to as the lean NOx trap (LNT). The LNT is a periodically-operated adsorptive reactor and comprises a bifunctional catalyst with deliberate periodic operation in which the air fuel ratio is altered between lean (oxygen excess) and rich (fuel excess) mixtures. During the storage phase, NOx is incorporated into the alkali earth storage component as a mixture of nitrites and nitrates through a complex set of steps that involve NO oxidation to NO2 on the precious metal (Platinum), followed by nitration of the alkali earth carbonate, among other pathways. Just before breakthrough of NOx in the reactor effluent, a net-reducing mixture is fed to the trap either by temporary rich operation of the lean burn engine or by direct injection of reductant (fuel) into the exhaust system. During this regeneration or purge phase the injected hydrocarbon serves the dual role of consuming the excess oxygen and of reducing the nitrites/nitrates. The NOx reduction chemistry primarily occurs on the precious metal through a selective catalytic reduction process forming a mixture of nitrogen and N2O as the N containing products. Upon regeneration of the storage component, the feed is switched back to the net oxidizing feed and the cycle is repeated. In this study, we simulate the effect of various parameters on the working of the NOx trap by using a generic two-phase, 1-D model describing detailed chemistry of adsorption, desorption and reaction of different species. This detailed kinetic model includes the storage of oxygen (on ceria) and NOx in the washcoat during the lean phase, followed by combustion of hydrocarbon and reduction of NOx during the rich phase. We compare the steady state operation with the cyclic operation and predict that there is a feed temperature window where cyclic operation gives high NOx conversions. Several design and operating parameters are varied to study how the NOx conversion efficiency of the LNT varies and to find out the optimal operating strategy for achieving the best fuel economy. The parameters studied include the feed reactant fraction, cycle timing and temperature. The results from this study are compared with the experimental results and found to follow the same trends.