SAE TRANSACTIONS

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Methods for Fast Catalytic System Warm-Up During Vehicle Cold Starts

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ABSTRACT

Catalytic exhaust-control systems must be designed to operate at high efficiency almost from the moment of engine startup. Catalysts must reach their operating temperature as quickly as possible. Therefore, the utility of different methods for improving the warmup characteristics of catalytic systems is illustrated.

A very elegant method to speed the warmup is the use of the engine itself as a "preheater" for the catalytic converters. High exhaust gas enthalpy to raise exhaust system mass up to its operating temperature is obtained by the use of extreme spark retard, stoichiometric mixtures, and fully opened throttle. Intensive studies to investigate the effects of concurrent changes of spark timing and air/fuel mixtures on exhaust gas temperature, enthalpy, NO_x and HC emissions are discussed.

Finally, NO_x catalyst characteristics are dealt with, because the NO_x catalyst is the first in a dual-bed catalytic system. The NO_x catalyst should have high activity, low-ignition temperature, and good warmup performance. If the NO_x catalyst has a fast warmup rate, this would result even in a significant improvement in the warmup characteristic of the HC/CO bed.

TO ACHIEVE the emission targets prescribed by law for 1975-1976 a number of emission concepts with conventional internal combustion engines and emission control systems have been examined by the automotive industry. Catalytic converters, thermal reactors, and a combination of these two have been considered as emission control systems (1)*. Low emission values have been attained with these concepts when the engine is under warm working condition. However, the difficulties lie mainly in the warmup phase during cold vehicle startup.

To improve the overall effectiveness of catalytic systems at vehicle startup, extensive experimental tests were carried out during the warmup phase on various afterburning systems by the Research Department of the Volkswagenwerk AG. The intent of this paper is to illustrate the utility of improving the warmup characteristic of catalytic emission-control systems for achieving very low emission levels.

*Numbers in parentheses designate References at end of paper.

WARMUP METHODS FOR CATALYTIC SYSTEMS

Catalytic emission-control systems described in this paper operate mainly with the dual-bed catalytic process. The first bed contains the reduction catalyst which reduces the oxides of nitrogen (NO_x) by carbon monoxide (CO), hydrogen (H_2), and hydrocarbons (HC) which are present in the exhaust gases. The reaction between NO_x and CO will only take place providing that the amount of oxygen (O_2) present in the exhaust gas is strictly limited to low concentrations. This oxygen limitation is met by adjusting rich fuel/air mixtures.

The second catalyst bed contains the oxidation catalyst which burns the CO and HC after introducing secondary air between the first and second beds. The quantity of secon-

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