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Chemical Engineering Research and Design

journal homepage: www.elsevier.com/locate/cherd

Catalyst 'light-off' experiments on a diesel oxidation catalyst connected to a diesel engine—Methodology and techniques

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ABSTRACT

A methodology was developed, which helped to investigate the 'light-off' characteristics of a real diesel oxidation catalyst (DOC) while it was connected to a diesel engine. As a demonstration of the technique, trials were performed on a Ford 2.0 L engine, with a Pt on γ-alumina DOC (o.d. = 106 mm; length = 114 mm). By operating the engine at a constant speed (e.g. 2000 rpm), it was shown that when the engine torque was varied (e.g. from 5 to 47 N m), the gas inlet temperature to the DOC could also be varied (e.g. from 146 to 285 °C), while the gas composition and the mass flow of gas remained relatively constant—this enabled more scientific studies of catalyst 'light-off' to be performed on a real exhaust system. Experiments were also performed with higher background levels of a reactant (e.g. CO concentrations = 3000, 4000 and 5000 ppm), and hysteresis between 'light-off' and 'light-down' was observed. It was also shown how valuable additional information may be obtained from experiments using a thin-slice DOC (o.d. = 106 mm; length = 5 mm), and the CO inhibition effect was demonstrated on a real engine exhaust.

Keywords: Diesel oxidation catalyst; Light-off; CO oxidation

1. Introduction

In order to control emissions from a diesel engine, a diesel oxidation catalyst (DOC) is used. This in general consists of a support structure through which the exhaust gas flows. The support structure may be a monolith (e.g. ceramic cordierite), which contains a large number of parallel channels that are coated with a high surface area washcoat (e.g. γ-alumina) that in turn supports the active catalytic ingredient(s), e.g. Pt. The primary function of the DOC is to selectively oxidize pollutants such as CO and a wide range of hydrocarbons. The performance characteristics of a DOC and how they compare with catalytic converters for petrol engines are described in many literature sources (e.g. Lox and Engler, 1999; Twigg and Wilkins, 2006).

The need to respond to government legislation to reduce emissions from vehicles places increasing demands on the automotive industry to seek improvements in the design of catalytic converters. Catalyst development for DOCs is very challenging and involves a combination of experimental techniques performed both on a small scale (e.g. Salomons et al., 2006) and on a large scale (e.g. Knafl et al., 2006; Kim and Kim, 2009). In small-scale experiments, synthetic gas mixtures are usually used to simulate engine emissions, whereas in full-scale trials the DOC is connected to a live diesel engine. Much of this investigative work is supported by mathematical modelling studies, which may focus on reaction mechanisms (e.g. Chatterjee et al., 2001) and/or on the performance of the converter (e.g. Ahmadinejad et al., 2008).

In this paper, we focus on the challenge of performing experiments on a DOC, so a few examples are selected for a

Abbreviations: DOC, diesel oxidation catalyst; CPSI, cells per square inch; PVRC, Powertrain and Vehicle Research Centre; THC, total hydrocarbon; EGR, exhaust gas recirculation; LHHW, Langmuir–Hinshelwood–Hougen–Watson; NEDC, New European Driving Cycle.

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Received 7 March 2011; Received in revised form 13 September 2011; Accepted 8 October 2011
0263-8762/$ – see front matter © 2011 Published by Elsevier B.V. on behalf of The Institution of Chemical Engineers.
doi:10.1016/j.cherd.2011.10.003