



Thermo-mechanical fatigue damage and failure of modern high performance diesel pistons

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ABSTRACT

This study resulted from an engineering failure investigation related to diesel engine piston failures which occurred during a bench dynamometer engine durability test programme. The test programme aimed at evaluating the effects of various fuel types on the durability of fuel system components in passenger car diesel engines. A number of unexpected cylinder head, turbocharger and piston failures were experienced during the course of the test programme. This study focused on the cause of the piston failures experienced during these tests.

Analyses of the fractured pistons revealed that thermo-mechanical fatigue initiation occurred as a result of primary silicon phase cracking and subsequent micro-crack formation due to excessive thermo-mechanical loading. Progressive formations of such micro-cracks lead to flaws that were of sufficient magnitude to initiate propagation by high cycle fatigue mechanisms.

The investigation also revealed that the excessive thermo-mechanical piston loading was caused by over-fuelling and a combination of elevated and poorly controlled post inter-cooler air temperature. There was no evidence to suggest that the failures were related to the test fuel formulations.

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1. Introduction

In 2006, Sasol Technology (Pty.) Ltd., initiated an endurance test programme aimed at evaluating the effects of various fuel types on the durability of fuel system components in modern passenger car diesel engines. The programme screened test fuels for any wear, cavitation, fouling, deposits or other detrimental effects on these fuel system components. Engine oil performance was also examined. The programme comprised of repetitions of an extremely harsh 33 min speed and load cycle, with a total test duration of 1000 h and subsequent inspection of fuel system components. Details of these turbo-charged and intercooled, common rail diesel engines, the test cycle set-up and test results from this test programme have been provided [1,2] and results from the broader “fit-for-purpose” test series (including these endurance tests) are also available [3].

A number of unexpected cylinder head, turbocharger, piston ring and piston failures were experienced during the course of the tests. Details of the failures and times of occurrence are given in Table 1. Of the four engines (and four associated fuels) tested, Engine B was run on a standard European low sulphur diesel fuel conforming to EN590 specifications and was regarded as the reference in the programme.

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