EXPLORATION OF THE HIGH LOAD LIMITS IN DUAL-FUEL COMBUSTION OPERATION

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INTRODUCTION

To enhance the use of natural gas, dual-fuel type of combustion is introduced. The performance of the dual-fuel engine changes at high load. The challenge was to obtain load as high as possible while simultaneously satisfying the limiting values such as pressure rise rate, knock occurrence and in-cylinder peak pressure. Such operation contributed to better understanding of the control parameters for the dual-fuel operation at high load. With various operating conditions this research presents a comprehensive set of experimental results obtained with the conventional dual-fuel operation (diesel/natural gas) at boosted intake conditions. Experimental setup on which this research is performed consists of SI engine, AC Dyno, and various measurement devices including the indicating equipment for IGE engine.

EXPERIMENTAL TESTING

Experimental testing described in this paper comprise out of high load operating points at three different engine loads, IMEP = 10 bar, IMEP = 11 bar and IMEP = 13 bar. All operating points were measured at same engine speed of 1600 rpm, boosted intake pressure and for two different NG mass fractions: 90% NG and 95% NG. From the tests the in-cylinder peak pressures were monitored because the mechanical load on cylinder was limited to 120 bar. As the boosted pressure was obtained from external mechanical compressor in order to have data comparable with the data that would be obtained from engine with turbocharger, a pressure at the turbine inlet was calculated by an engine simulation model and applied to the engine exhaust by the exhaust valve during the measurements.

RESULTS

From the results presented in previous section the operating points with highest efficiency are selected for each load and NG mass fraction and are analysed in more details. The comparison of indicated efficiency for three different engine loads for both 90% NG and 95% NG mass fraction.

CONCLUSIONS

In this research, the DF combustion at high load boosted intake conditions was experimentally investigated. Engine performance and emissions were studied and the following conclusions are drawn:

- At constant excess air ratio for observed load range, the higher indicated efficiency is obtained with higher NG mass fraction.
- Indicated efficiency was increased with the increase of engine load.
- Optimal excess air ratio was decreased with the increase of engine load.
- NOx emission was reduced with higher excess air ratio.
- 90% NG mass fraction operating points show increase in NOx emission with the increase of engine load.
- 95% NG mass fraction operating points also show increase in NOx emission with the increase of engine load.
- THC emissions were increased with the higher excess air ratio.
- THC emissions decrease with the increase of engine load.

ACKNOWLEDGEMENTS

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Table 1. Engine specifications

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>Kuzi, 1081</th>
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<tbody>
<tr>
<td>Engine type</td>
<td>4-cylinder 4-stroke</td>
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<tr>
<td>Bore, mm</td>
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<tr>
<td>Stroke, mm</td>
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<tr>
<td>Connecting rod length, mm</td>
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<td>Compression ratio, -</td>
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<tr>
<td>Gas injector</td>
<td>Hana H2001</td>
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<tr>
<td>Diesel injector</td>
<td>Bosch CR13</td>
</tr>
</tbody>
</table>

Figure 4. Indicated efficiency, intake pressure, SOI and excess air ratio for the operating points with IMEP = 11 bar and 90% NG mass fraction.

Figure 5. Indicated efficiency, intake pressure, SOI and excess air ratio for the operating points with IMEP = 13 bar and 90% NG mass fraction.

Figure 6. Indicated efficiency, intake pressure, SOI and excess air ratio for the operating points with IMEP = 13 bar and 90% NG mass fraction.

Figure 7. Indicated efficiency, intake pressure, SOI and excess air ratio for the operating points with IMEP = 13 bar and 90% NG mass fraction.

Figure 8. Indicated efficiency for three different engine loads with 90% and 95% NG mass fraction.