

Abstract

Hydrogen fuelled engine emits zero level emissions along with high thermal efficiency. Many studies are reported on the evaluation of the performance and emissions characteristics of a hydrogen fuelled spark ignition engine with shorter tests duration and a long durability study on the engine is scanty. Hence, the durability study is aimed at the assessment of the hydrogen fuelled engine's performance and emissions, components' tear and wear, and engine oil's performance. This is an important topic to investigate if hydrogen is expected to play an important role in fueling IC engines of the future.

A constant speed multicylinder spark ignition engine generator set with timed manifold hydrogen injection was used for this study. The performance of three different test oils formulations (namely A, B, and C) with different additive packages such as kinematic viscosity, Total Base Number (TBN), etc. was studied and a suitable engine oil among three candidates for the hydrogen fuelled engine was developed based on better performance and emissions of the engine with a shorter test of 20 hours (cyclic load constant speed of 1500 rpm) of each test oil and the frictional coefficient. NO_x emission and the particle number (PN) were measured for the assessment of emission characteristics of the engine.

The results indicated that test oil-A was with 1-2% lower BSFC at low load range, 3-4% lower BSFC at middle load range, and 5-6% BSFC at higher load range compared with test oil samples B and C. Also, test oil-A was with the lowest NO_x emission and particle number compared with test oils B and C. The tribological testing demonstrates that the test oil-A was with the lowest friction coefficients. Based on the used engine oil analysis conducted after completion of short-duration performance test of 20 h, the kinematic viscosity at 40°C and 100°C, total base number, total acid number, and water content of the test oil-A was lower as 3.89%, 2.15%, 5.71%, 2.0%, and 6.75% compared to test oils "B" (4.67%, 4.01%, 13.14%,

4.71%, and 7.69%) and “C” (6.56%, 4.33%, 6.0%, 5.0% and 12.39%). Hence, the test oil-A indicates better performance in terms of BSFC, NO_x emission, particle number, etc. Thus, the test oil-A was shortlisted for the endurance studies.

The long-duration endurance test was conducted on hydrogen-fuelled SI engine to assess its performance and emissions for a duration of 512 hours (32 numbers of test cycles x 16 h/test cycle) as per IS 10000 (Part IX) (cyclic load constant speed of 1500 rpm) as well as to determine the drain interval of engine oil. A sample of used engine oil was collected at every 48 hours interval to analyze its characteristics like KV at 40°C and 100°C, TBN, TAN, sulfation, oxidation, nitration, wear metals, and water content.

It is observed from the results that the emissions such as CO, CO₂, THC, PN formed due to oxidation of the lubricating oil. The depletion in TBN due to corrosive wear and rise in TAN due to high acidic component formation were within the permissible rejection limits. The nitration in engine oil dominates compared to oxidation and the wear elements such as Fe, Cr, Cu, Ni, Al, Pb, and Sn, and water present in the engine oil (0.05-0.1%) were within the permissible rejection limits. Suitable engine oil and an appropriate test method for its assessment are developed for hydrogen fuelled spark ignition engine.