Performance and emissions of natural gas/diesel dual-fuel engine at low load conditions: Effect of natural gas split injection strategy

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ABSTRACT

The combination of diesel and natural gas fuels has superior performance in terms of nitrogen oxides (NOx) and particulate matter (PM) emissions when compared to conventional diesel engine. However, this advantage does not hold at low load operating conditions as indicated thermal efficiency (ITE), carbon monoxides (CO), and unburned hydrocarbon (HC) emissions deteriorate. Most published studies tried to resolve this drawback using diesel split injection. However, the present study evaluates natural gas split injection strategy as an alternative to improve the performance and emissions of diesel/natural gas dual-fuel engines at low load conditions. The results show that natural gas split injection with proportional split injection ratio (ISR) and small dwelling timing improves NOx, CO, and HC emissions. Moreover, split injection of natural gas with proportional ISR after intake valve closing (IVC) is found to improve SFC, ITE, and power. Conversely, natural gas split injection strategy with proportional ISR after intake valve opening (IVO) yields poor engine performance. Overall, split injection of natural gas with low ISR yields the greatest engine performance at long dwelling time, whereas it worsens emissions compared to single injection of natural gas at 560°CA ATDC, which serves as the baseline condition. However, very low CO and HC emissions of natural gas split injection is achieved at low ISR and short dwelling time. Finally, this study reveals also that stratification of air/natural gas mixture due to natural gas split injection strategy can significantly improve the performance and emissions of dual-fuel diesel/natural gas engine at low load conditions.

KEYWORDS

Diesel; Dual-fuel; Low load; Natural gas; Single injection; Split injection

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