Abstract

Most automotive engines work in bi-fuel mode, which runs on both gasoline and CNG. However, the higher compression ratio (CR) is not used in CNG mode due to design constraints. When CNG is injected into the manifold, it displaces intake air lowering engine's volumetric efficiency. Thus, a higher compression ratio and a method to increase the volumetric efficiency of the CNG engine are needs of the hour.

The CR of the engine was varied to find maximum CR and corresponding operating regime for port fuel injection (PFI) gasoline and PFI CNG engine. The end of injection (EOI) was varied to study its effect on PFI gasoline and PFI CNG engine performance. A direct injection technique (DICNG) was adopted to evaluate the improvement in volumetric efficiency and power output. The effect of EOI time was quantitatively investigated for optimum turbulence and an improved air-fuel mixture. Machine learning models were employed and optimized for engine output predictions.

The PFI gasoline and PFI CNG engine showed higher indicated thermal efficiency (ITE) at EOI timings corresponding to early and late intake stroke, respectively. The gasoline engine exhibited a higher knock at CR 12. Whereas CNG fuelled engine could operate up to CR 16. The ITE of the PFI CNG engine was 4 to 5% higher than gasoline engine. The PFI CNG engine's ITE increased to 35.86% at CR 16. The artificial neural network model was found appropriate with a coefficient of determination of 0.91 compared to polynomial regression and support vector machine models. The direct injection of CNG towards the end of the suction stroke and the start of the compression stroke increased the volumetric efficiency and turbulence inside the combustion chamber. A COV_{IMEP} below 3% was observed for DI CNG. The DICNG engine showed 2% higher ITE than PFI CNG engine. An excess air ratio of 1.3 and 1.4 could be achieved at CR 12 and 16, respectively, with a higher ITE over the stoichiometric operation in DICNG engine. The thesis also uses numerical simulations to enhance the background hypothesis of the experiments conducted for PFI gasoline, PFI CNG, and DICNG engines.