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ORIGINAL ARTICLE

Effect of Ignition Delay (ID) on performance, emission and combustion characteristics of 2-Methyl Furan-Unleaded gasoline blends in a MPFI SI engine

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Abstract The major issue faced today is the atmospheric pollution by the gases released by vehicles. 2-Methyl Furan (MF) is one such promising alternative that has potential to serve the purpose. The main objective of this experiment was to investigate the effects of adding MF in a four-stroke MPFI SI engine in terms of its performance, emission and combustion characteristics. Unleaded gasoline (UG) along with 3 concentrations of MF (M10, M20 and M30) blended with UG were used as test fuels. The tests were conducted at a constant load of 20 N m with the speed ranging from 1400 to 2800 rpm with an increment of 200 rpm. When the blend percentage increased there was a decrease in CO and HC emissions with an increase in the BTE and NO_x emissions. The curve for the pressure and the maximum rate of heat release shifted towards left reducing the ignition delay with the addition of blends. When the ignition timing was retarded slightly by 2°Crank Angle (CA) to counter the NO_x, the BTE and NO_x emissions were comparatively lesser as expected. On the other hand, CO and HC emissions showed a gradual rise and maximum value of peak pressure and heat release occurred little later.

1. Introduction

Currently, the global concern among the researchers is the atmospheric pollution which is caused as a consequence of vehicular and industrial emissions. The noxious and detrimental gases have adverse effects on all living beings. The science of air pollution mainly deals with predicting the concentrations and their adversities on the environment. Over the past half-century, scientists have learned much more about the causes and impacts of air pollution [1]. The key elucidation to this subject is the use of alternatives which include hydrogen, natural gas, alcohols, ethers, etc. Among the alternatives, oxygenates have proven their potential without any compromise in power.

Gravalos et al. [2] studied the emission characteristics of a single-cylinder, SI engine operating on lower-higher molecular mass alcohol blended gasoline fuels. The concentrations of

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Nomenclature

UG	100% unleaded gasoline	CA	Crank Angle
M10	10% 2-methyl furan + 90% unleaded gasoline	HRR	heat release rate
M20	20% 2-methyl furan + 80% unleaded gasoline	HC	hydrocarbon
M30	30% 2-methyl furan + 70% unleaded gasoline	CO	carbon monoxide
MPFI	multi-point fuel injection	CO_2	carbon dioxide
SI	spark ignition	NOx	oxides of nitrogen
O/C	ratio of elemental oxygen to elemental carbon	aTDC	after top dead center
H/C	ratio of elemental hydrogen to elemental carbon	BSFC	brake specific fuel consumption
BTE	Brake Thermal Efficiency	NO	nitric oxide

methanol, propanol, butanol and pentanol were kept constant at 1.9%, 3.5%, 1.5% and 1.1% respectively. The concentration of ethanol was varied (7%, 12%, 17%, 22%) and the remaining was unleaded gasoline. There was 20.4% decrease in HC emission between unleaded gasoline and blend with 17% ethanol. The HC emissions decreased with the increase in speed and CO emission decreased with increase in ethanol. In another experiment, higher molecular mass alcohols were removed and experiment was carried out with lower molecular mass alcohols. The lower mass alcohols emitted comparatively lower NO_x and CO_2 emission and higher CO emissions than higher molecular mass alcohols. Elfasakhany and Mahrous [3] had assessed the performance and emission characteristics of *n*-butanol-Methanol-Gasoline blends in a SI engine. They found that dual alcohols at lower blend percentage showed higher CO and UHC emissions compared to single alcohol and gasoline blend. When the volumetric content was increased to 10%, the engine performance was improved and the exhaust emissions were higher. They had concluded that single alcohol should be used at lower blending percentages and dual alcohol should be used at higher blending percentages.

Wang et al. [4] have investigated the PM composition and soot oxidation in a 1-cylinder spray guided DISI engine with thermo gravimetric analysis (TGA) technique. The PM emissions mainly consisted of volatile compounds rather than soot even at high engine load operation. The soot from oxygenated fuels was oxidised easily than gasoline indicated by activation energies. As the load increased, the activation energy and temperature needed to oxidise soot increased, indicating that it is difficult to oxidise soot if it is formed at higher temperature. Lee et al. [5] had investigated the performance and emission characteristics of a SI engine fuelled with DME blended LPG fuel. It was found that higher DME percentages had decreased the engine torque and increased the BSFC of the engine. In addition to that, the HC and NO_x emissions were increased slightly with blended fuels at lower engine speeds. They also found that the knock occurrence area had increased substantially with higher blending percentage of DME.

Song et al. [6] compared the effects of MTBE with ethanol (EA) and their emissions in SI engine. The acetaldehyde emissions were the same for both fuels at lower speed whereas MTBE had higher emissions than EA at higher speeds. When the emissions were regulated, then EA had better performance than MTBE, but the effects were reversed at unregulated emissions. Hsieh et al. [7] studied the performance and emissions of ethanol-gasoline blends on SI engines. The torque and BSFC were found to increase with ethanol addition. There was a drastic decrease in the CO and HC emissions as a consequence of complete combustion. There was a rise in CO_2 level with ethanol addition which infers good combustion quality.

Shenghua et al. [8] studied the performance, emission and combustion characteristics of a 3-cylinder port fuel injected SI engine with methanol-gasoline blends. It was found that the power and torque decreased with methanol-gasoline blend. CO and HC emissions also decreased and the NO_x emission had changed slightly. HC emissions were reduced more than 50% for the first few seconds of cold-start and nearly 30% for the remaining time. CO had reduced by 25% when fuelled with M30. The start of combustion was advanced due to the methanol addition and on the other hand the rapid burning phase became shorter. The thermal efficiency of methanol blends was higher due to its higher laminar flame propagation. It was concluded that the engine was stable when methanol blends were lower in gasoline. Elfasakhany [9] investigated SI engine fuelled with hybrid iso-butanol/gasoline fuel blends. At lower speed, the CO and UHC emissions were reduced by 30% and 21% respectively for iB10 compared to gasoline. The CO emissions were found to decrease till a speed of 2900 rpm and the trend began to increase thereafter above 2900 rpm. Such characteristics depicted the reduced availability of combustion time at higher speeds. Wang et al. [10] have compared the combustion and emission characteristics of MF with gasoline, DMF and ethanol in a single-cylinder, DISI engine. Experiments were conducted at stoichiometric air-fuel ratio with engine speed of 1500 rpm and loads between 3.5 and 8.5 bar IMEP. MF consistently produced higher indicated thermal efficiency by some 3% compared to gasoline and DMF. MF can even be used in higher compression ratio SI engine because of its better knock suppression. Among the four studied fuels, MF had a much faster burning rate, which makes its combustion duration the shortest. At 8.5 bar IMEP, MF was about 7, 3 and 2 CAD shorter than gasoline, ethanol and DMF respectively. The peak pressure value was the highest for MF and it produced 73% and 40% less HC emissions than gasoline and DMF respectively. NO_x, on the other hand had increased significantly.

Wei et al. [11] experimentally investigated on the combustion and emission characteristics of 2-methyl furan and gasoline blended fuel in SI engine. It was found to produce a higher peak pressure and higher temperature than gasoline. It had higher knock resistance and thus can be used in various compression ratios of SI engine. The HC and CO were reduced to a significant extent. The blend M10 has produced a 10.3%