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COMBUSTION OPTIMIZATION IN SPARK IGNITION ENGINES

Barhm Mohamad[1], Gabor Szepesi[2], Betti Bollo[3]

[2,3]Doctor of Mechanical Engineering

[1, 2, 3] *Miskolc University, Faculty of Mechanical Engineering and Informatics, 3515 Miskolc, Hungary*

ABSTRACT

The blending technique used in internal combustion engines can reduce emission of toxic exhaust components and noises, enhance overall energy efficiency and reduce fuel costs. The aim of the study was to compare the effects of dual alcohols (methanol and ethanol) blended in gasoline fuel (GF) against performance, combustion and emission characteristics. Problems arise in the fuel delivery system when using the highly volatile methanol - gasoline blends. This problem is reduced by using special fuel manifold. However, the satisfactory engine performance of the dual alcohol–gasoline blends need to be proved. The test fuels were GF, blend M35g65 (35 % methanol, and 65% GF by volume), blend E40g60 (40% ethanol, and 6o% GF by volume). The blend M35g65 was selected to match the vapor pressure (VP) of GF. The test fuels were a lean mixture with excess-air ratio of λ=1.1. The reaction parameters are taken from literatures and fitting calculations. Mathematical model and Computer software AVL program were conducted on a naturally-aspirated, spark ignition engine. The results show that indicate thermal efficiency (ITE) improved whereas the exhaust gas temperature (EGT) of the blends reduced, which is a benefit that reduces compression work. The regulated emissions were also reported. The blend E40g60 was recommended in preference to use because the former had shortened combustion duration, high energy content and its VP was selectively matched to that of GF's.

1. INTRODUCTION

Due to the multiple advantages, such as high specific power, low noise and vibration, gasoline engine has been widely used as the power source of automobile. In China, about 80% of automobiles take the gasoline engine as power. Owing to the increasing energy crisis and environment pollution, energy conservation and emission reduction have become an important development strategy in the world. Therefore, to promote the fuel economy and emission performance of gasoline engine is not only the requirement of energy conservation and emission reduction, but also the demand for the survival of traditional gasoline engine [6]. Only by continuously improving the combustion and emission performance of gasoline engine, that allowed to study and Identify the noise and vibrations occur from combustion process during change of exhaust gas behavior so that the traditional gasoline engine continue to hold the leading position in the future transportation. Environmentally friendly alternative or renewable fuels are taking the center stage globally in the search for greener combustible fuels for use in internal combustion engines [8].

Some of the chemical and physical properties of methanol, ethanol and gasoline are presented in Table 1.

Table 1
Properties of methanol, ethanol and gasoline fuel. [1, 3]

	Methanol	Ethanol	Gasoline
Molecular formula	CH_3OH	C_2H_5OH	-
Oxygen content (%)	50	46	95–120
Density kg/m^3	792	785	740
LHV MJ/kg	20	26.9	44.3
Octane number	111	108	>90
Auto-ignition temp.(°C)	465	425	228–470
Stoichiometric A/F (λ) ratio[kg/kg]	6.47	9.0	14.8
Latent heat kJ/kg	1103	840	305
Vapor pressure at 23.5 °C (kPa)	3.2	-	60–90

Blends in this study, the performance and combustion characteristics and regulated emissions, for methanol gasoline blend designated as M35g65 (35% methanol and 65% GF by volume (v/v)), The simulation results were evaluated by comparison with field data collected from other experimental and mathematically evaluated [1, 7]. The other blends tested were: E40g60 (40% ethanol and 60% GF by volume).

2. MATHMATICAL MODEL

The parameters are taken from literatures experiments were performed using each single alcohol–gasoline blends in turn at steady state (see Table 2). The multi-cylinder engine was operated with pure gasoline, M35g65 and E40g60 to investigate the combustion and exhaust emission characteristics. The speed was set to 2000 RPM as it represents the operating condition for the average pulse width of fuel–mass injected for this engine within the range 2000 RPM. The dependent variables included: in-cylinder pressure, heat release rate (HRR) and emissions of NO_x, UHC, CO, and CO_2.

The gasoline – alcohol blends was selected by a formula proposed by [2] to satisfy the vapor pressure requirement for automotive fuels as follows:

$$C_i = \left(\frac{P_{Gasoline} - P_j(C_{tot})}{P_i(C_{tot}) - P_j(C_{tot})}\right) . C_{tot} \qquad (1)$$

Where,

C_i :volume fraction (v/v) % of the alcohol i,

C_{tot} : the total alcohol volume fraction (v/v) %,

$P_{gasoline}$: the vapor pressure of the base gasoline,

$P_i(C_{tot})$: VP of the single alcohol i at C_{tot},

$P_j(C_{tot})$: VP of the single alcohol j at C_{tot},

i and j : alcohol components i and j.

The volume of the solution depends on its composition, it is convenient to discuss volumetric effects of Gasoline - Alcohol mixtures in terms of partial molar volume. The partial molar volume, V_i, is defined as follows:

$$V_i = \left(\frac{\partial V}{\partial n_i}\right)_{T,\, p,\, nj} \qquad (2)$$

The equation above provided by Pecar & Dolecek can be stated by saying that V_i is the change in total volume per mole of "i" added, when some amount of "i" is added to the mixture at constant temperature, pressure and amount of other substances. Using partial molar volumes, the total volume of a solution can be given by the following equation:

$$V_T = V_1 n_1 + V_2 n_2 + \ldots + V_N n_N \qquad (3)$$

$$V_T = \left(\frac{\partial V}{\partial n_1}\right)_{T,\, p,\, nj} * n^1 + \left(\frac{\partial V}{\partial n_2}\right)_{T,\, P, nj} * n_2 + \ldots\ldots + \left(\frac{\partial V}{\partial n_N}\right)_{T,\, p,\, nj} * n_N \qquad (4)$$

The total volume of the solution can be discovered by determining the partial molar volumes of ethanol and gasoline, as well as the mass fractions of the mixture.

3. COMBUSTION SIMULATION

The BOOST program package consists of an interactive pre-processor which assists with the preparation of the input data for the main calculation program. Results analysis is supported by an interactive post-processor. The pre-processing tool of the AVL Workspace Graphical User Interface features a model editor and a guided input of the required data.

Table 3
Engine specification and parameters.

Engine type	Four Stroke/ Spark Ignition Engine
Model	GTE 0.5L
Bore [mm]	86
Stroke [mm]	86
Connecting rod [mm]	143.5
Compression ratio [–]	1:10.5
Number of cylinders	4
Number of valves	8
Fuel type	Petrol-P
Fuel aspiration	Naturally aspirated
Fuel delivery	Multi-point injection

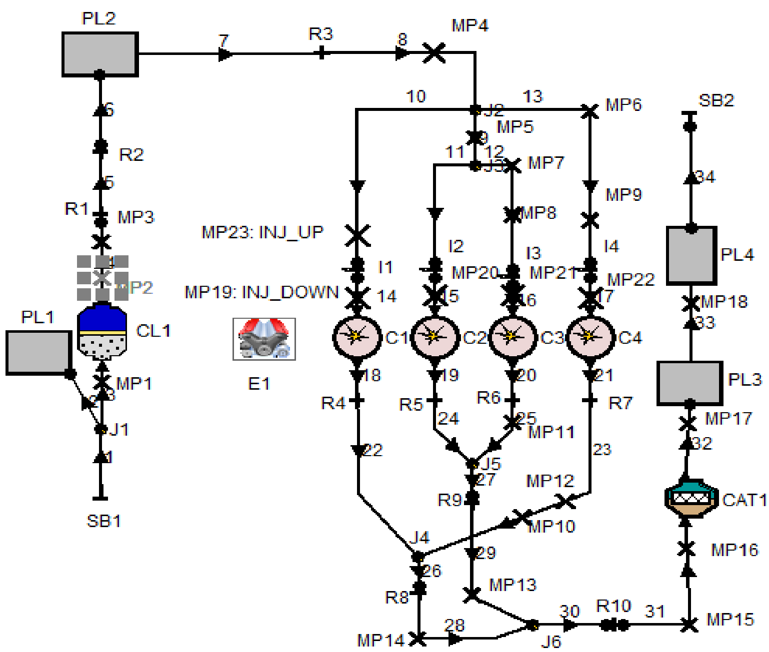

Fig.1

Engine structure and parts connection

4. RESULTS

It should be noted that in accordance with the literature data [2, 9, and 10] and calculation in the software package, Ethanol-Gasoline blend was identified to have the potential of generating a more appropriate atomization for internal combustion faster diffusion velocity which enhanced local homogeneity. In comparison to the Methanol-Gasoline blend due to a higher vapor pressure at high temperature conditions.

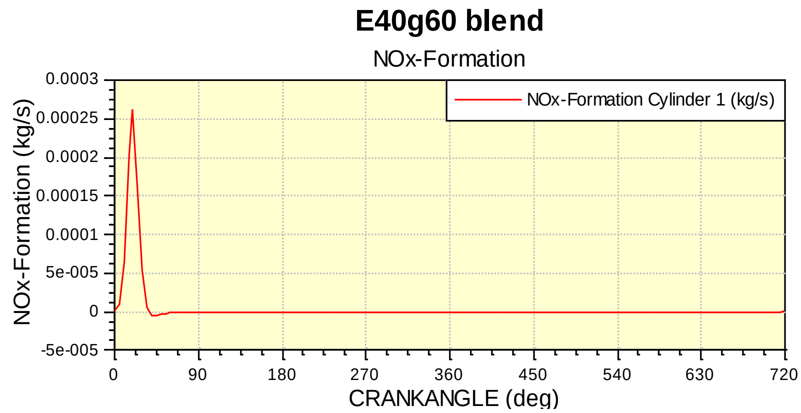

Fig. 2.a

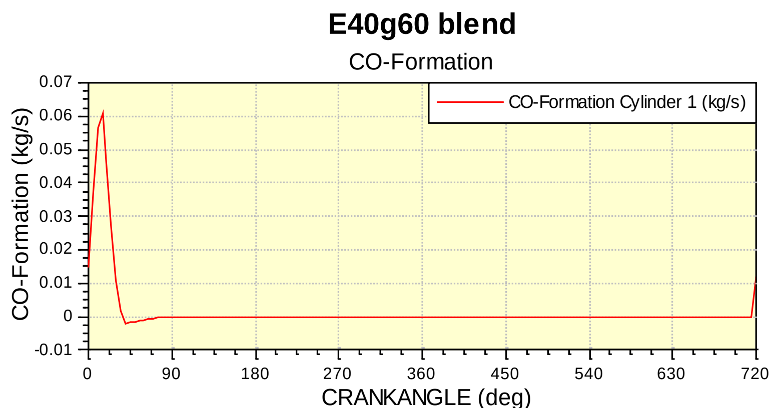

Fig. 2.b

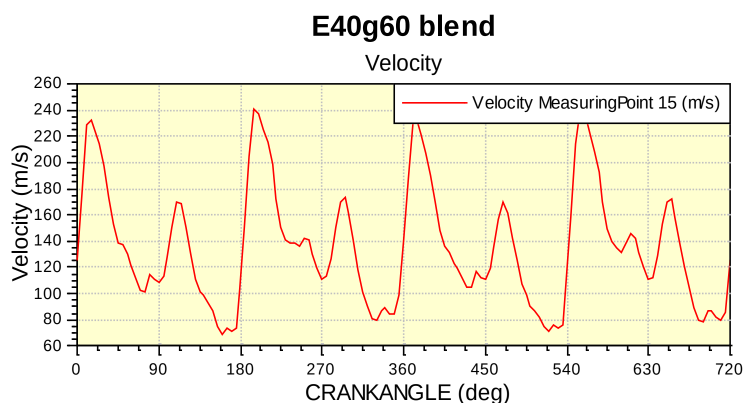

Fig. 2.c

a) NO_x Formation of E40g60 blend (b) CO Formation of E40g60 blend (c) Exhaust gas velocity

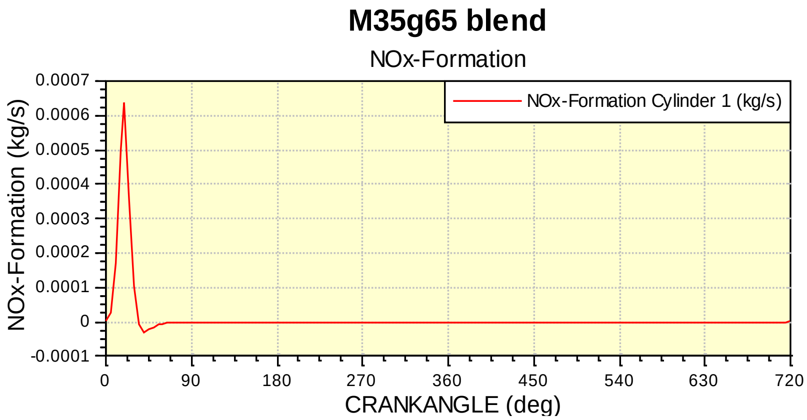

Fig. 3.a

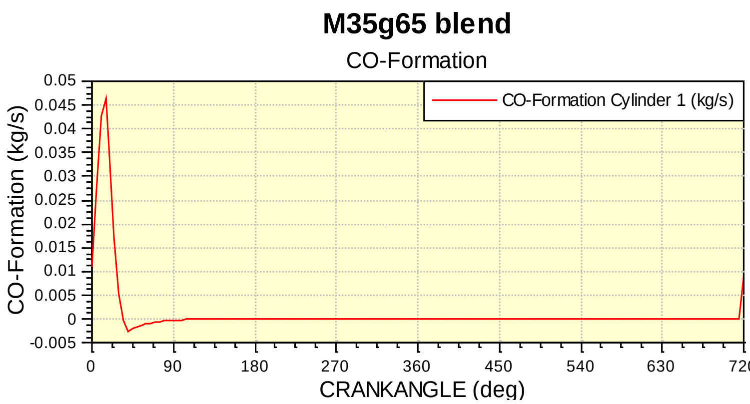

Fig. 3.b

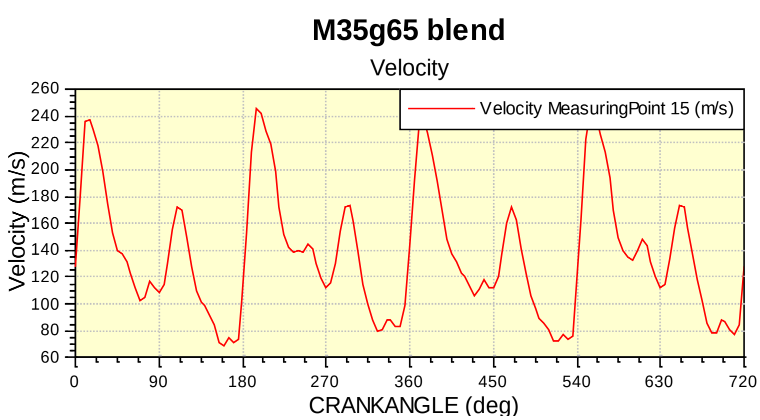

Fig. 3.c

(a) NO_x Formation of M35g65 blend (b) CO Formation of M35g65 blend (c) Exhaust gas velocity

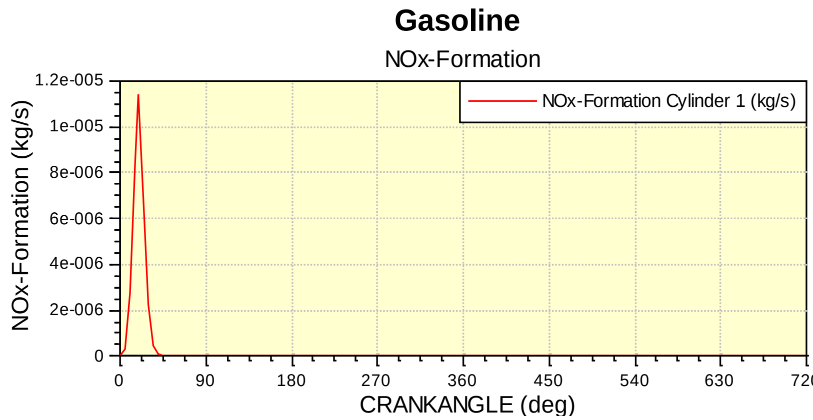

Fig. 4.a

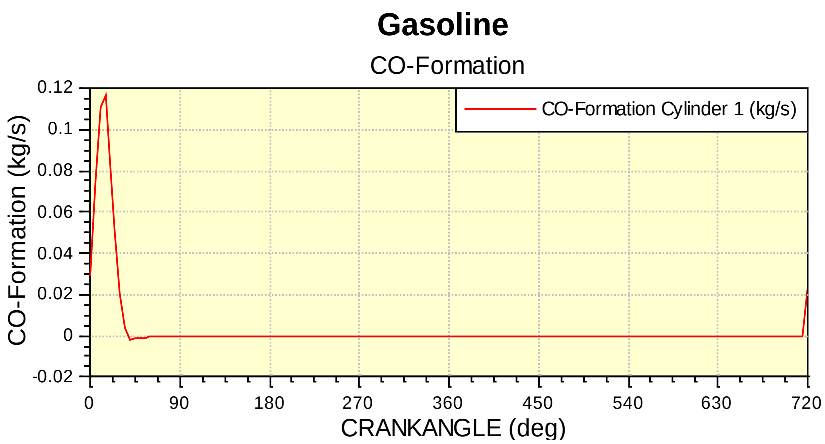

Fig. 4.b

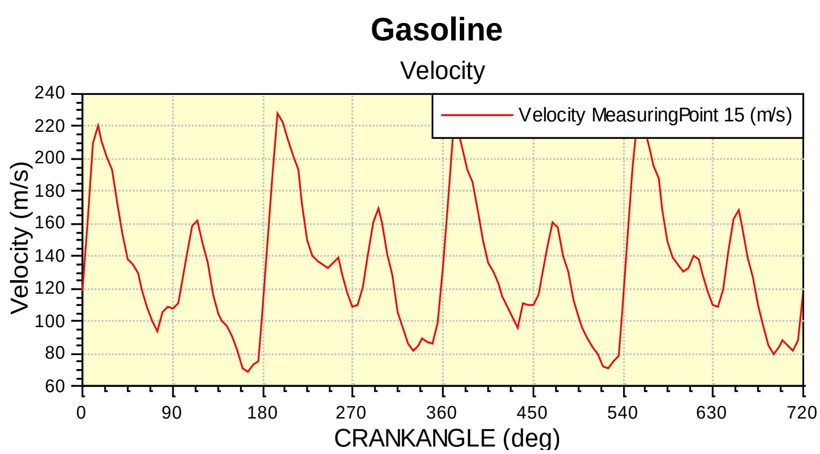

Fig. 4.c

(a) NO_x Formation of gasoline fuel (b) CO Formation of gasoline fuel (c) Exhaust gas velocity

5. CONCLUSION

Fig.2,3,4 shows the simulation results. According to these results can see that the ethanol-gasoline blend has a higher laminar flame propagation speed, which may make combustion process finish earlier and thus may improve engine thermal efficiency. The NOx emissions were decreased with ethanol blending due to the lower peak of in-cylinder temperature by the combustion retardation. The LHVs of methanol and ethanol are significantly lower than that of gasoline [12, 13]. However, the alcohol fuels show higher octane numbers, which is favorable to achieve higher thermal efficiency. Studies on the fuel consumption behavior between increased compression ratio and octane number fuel, showed that an octane number increment of approximately 4–6 [11]. The cooling effect itself can also contribute to increased knock tolerance and volumetric efficiency. The vapor pressure of gasoline is higher and the boiling point is lower than those of ethanol between the temperature ranges of 300–410 K. Therefore, engine stability and emission problems under cold-start condition need to be taken care of when implementing ethanol fuel. Combustion noise is generated due to pressure oscillations created inside the combustion chamber due to sudden heat release because of combustion of fuel. These pulses generate vibrations in the chamber walls, which radiate outwards as combustion noise. Provides a comparison of this noise for different test fuels. It is seen from this figure [Fig. 2b, 3b, 4b] that the noise generated by engine.

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