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Research Paper

Energy balance analysis of gasoline engine using different alcohols as additives in gasoline fuel

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1. ABSTRACT

The aim of this study was to evaluate the energy balance of a water-cooled, four-cylinder gasoline engine using gasoline and ethanol, butanol, propanol, and pentanol alcohols fuel blends in different volume percentages at three different speeds of 1000, 1500, and 2000 rpm. The results showed that the highest and lowest engine brake power was 47.11 kW at 2000 rpm and 21.81 kW at 1000 rpm related to fuel number 6 and fuel number 1, respectively. The highest amount of heat loss of the cooling system was 10.84 kW at 1000 rpm related to fuel number 6 and the lowest value was 7.47 kW at 1000 rpm related to fuel number 1. Also, the highest exhaust heat loss was 17.07 kW at 2000 rpm related to fuel number 6 and the lowest value was 14.54 kW related to fuel number 2 at 1000 rpm.

Keywords: Bio-alcohols, Renewable energy, Internal combustion engines.

2. INTRODUCTION

The rapid reduction of fossil fuels, the rapid process of environmental pollution by internal combustion engines, has motivated the discovery and evaluation of alternative fuels. The input energy will not be completely converted into useful work and approximately only 30% of the input energy will be converted into useful work [1]. The first law of thermodynamics (energy) is a method for evaluating the effective and efficient use of energy. The main parameters of energy balance are braking power, cooling system losses, exhaust heat losses and unaccounted heat losses [2]. The continuous use of fossil fuels has reduced their resources all over the world, and therefore many researchers in the world are looking for a solution to reduce the use of fossil fuels. So far, there has been no research on the energy balance of the engine using ethanol, butanol, propanol and pentanol compounds in different volume percentages. Therefore, in this study, the energy balance of a water-cooled, four-cylinder gasoline engine using gasoline and ethanol-butanol-propanol and pentanol fuel blends at speeds of 1000, 1500 and 2000 rpm was investigated and finally the data related to engine brake power, exhaust heat losses, cooling system losses and unaccounted losses were analyzed.

3. MATERIALS AND METHODS

The composition ratio of fuel blends is presented in Table 1.

Table 1. Ratio of fuel Blends.

Fuel Blends	Fuel Blends Name	Pentanol	Ethanol	Butanol	Propanol	Gasoline
$G_{60}Pe_{10}E_{10}Bu_{10}Pr_{10}$	1	10	10	10	10	60
$G_{40}Pe_{10}E_{10}Bu_{20}Pr_{20}$	2	10	10	20	20	40
$G_{55}Pe_{15}E_{10}Bu_{10}Pr_{10}$	3	15	10	10	10	55
$G_{35}Pe_{15}E_{10}Bu_{20}Pr_{20}$	4	15	10	20	20	35
$G_{50}Pe_{20}E_{10}Bu_{10}Pr_{10}$	5	20	10	10	10	50
$G_{30}Pe_{20}E_{10}Bu_{20}Pr_{20}$	6	20	10	20	20	30
G100	Instance	0	0	0	0	100

Energy balance calculations

To survey the thermal balance of the engine, it is necessary to evaluate engine brake power (P_b), exhaust heat loss (Q_{exh}), heat loss of the cooling system (Q_w) and unaccounted heat loss (Q_{un}). Considering the control volume around the engine, the energy conservation equation for the above parameters can be written:

$$Q_s=P_b+Q_w+Q_{exh}+Q_{un} \quad (1)$$

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$Q_s = \dot{m}_f \times Q_{LHV}$ (2)

Brake power (P_b) is actually the power on the flywheel, which is calculated from the following equation [1]:

$$Pb = \frac{2*\pi*N\left(\frac{rev}{s}\right)*T(N.m)}{10^3} \quad (3)$$

The heat loss of the cooling system (Q_w) is calculated from the following formula [3]:

$Q_w = \dot{m}_w \times c_w \times (T_2 - T_1)$ (4)

Exhaust heat loss (Q_{exh}) is calculated from the following equation [1]:

$Q_{exh} = (\dot{m}_f + \dot{m}_w) \times C_e \times (T_g - T_a)$ (5)

The unaccounted heat loss of the system (Q_{un}) which is calculated from the following equation [1]:

$Qun = Q_s - (P_b + Q_w + Q_{exh})$ (6)

4. RESULTS AND DISCUSSION

Engine braking power

Braking power in each fuel blends increases with increasing speed from 1000 to 2000 rpm (Figure 1). The reason for the increase in braking power and torque due to the addition of ethanol, butanol, propanol and pentanol alcohols to gasoline is related to the higher latent heat of vaporization of alcohols [4]. The highest braking power is related to fuel number 6 and the lowest braking power is related to fuel number 1.

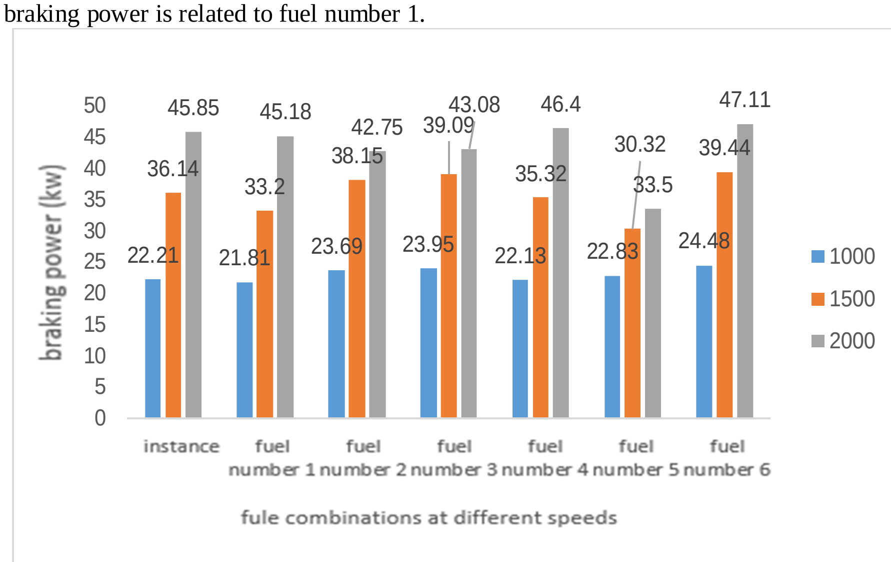

Figure 1. Engine brake power in different fuel blends.

According to Figure 2, cooling system losses in pure gasoline fuel decrease with increasing engine speed from 1000 to 2000 rpm. The highest amount of heat loss of the cooling system was 10.84 kW at 1000 rpm related to fuel number 6 and the lowest value was 7.47 kW at 1000 rpm related to fuel number 1.

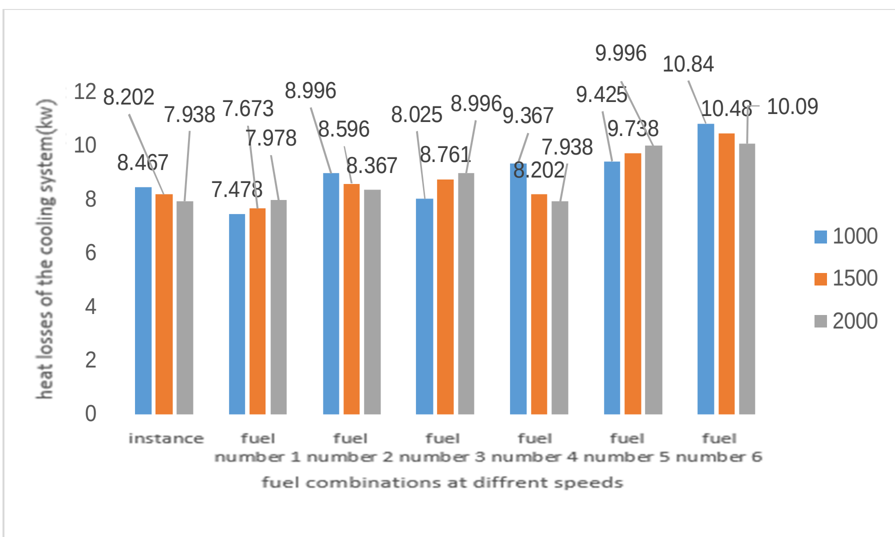

Figure 2. Heat loss of the cooling system in different fuel blends.

As the engine speed increases from 1000 to 2000 rpm in fuel blends, the amount of exhaust heat loss increases (Figure3). The highest exhaust heat loss was 17.07 kW at 2000 rpm related to fuel number 6 and the lowest value was 14.54 kW related to fuel number 2 at 1000 rpm.

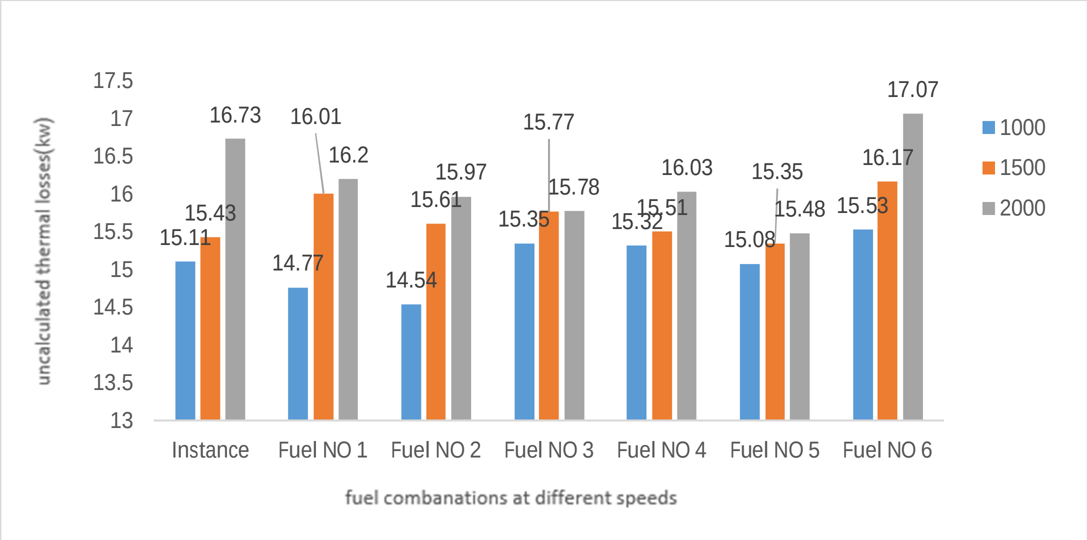

Figure 3. Exhaust Heat loss in different fuel blends

Pure gasoline fuel at 1000 rpm has the highest amount (18.71 kW) of unaccounted heat losses (Figure 4). For all blends, the unaccounted heat loss increases with the increase in engine speed.

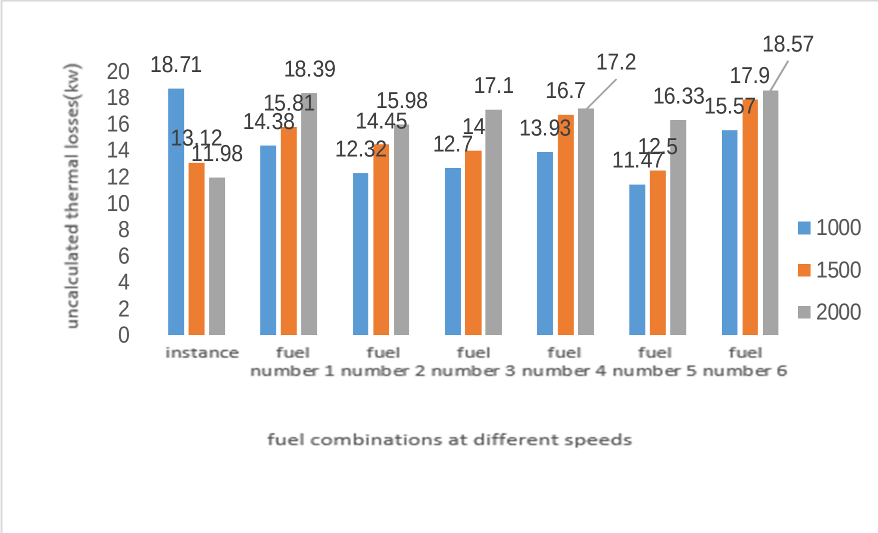

Figure 4. Unaccounted heat loss in different fuel blends

5. CONCLUSION

The following results are obtained from this study:

The trend of changes in braking power with the increase and decrease of pentanol had the opposite proportion. Engine speed and the amount of increase or decrease of pentanol in the fuel composition were influential in the losses of the cooling system. Exhaust heat losses decreased in compounds with low percentage of pentanol, and in some fuels, increasing the amount of butanol and propanol caused an increase in exhaust heat losses. Increasing engine speed caused an increase in engine heat losses, but increasing the amount of pentanol caused a decrease in uncalculated heat losses in some fuel combinations.

6. REFERENCES

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