Energy Conversion and Management 65 (2013) 751–754

Contents lists available at SciVerse ScienceDirect

Energy Conversion and Management

journal homepage: www.elsevier.com/locate/enconman

The reduction of soot formation from fuels using oxygenates additives

K.I. Burshaid [a], M.A. Hamdan [b,*]

[a] Department of Mechanical Engineering, The University of Jordan, Amman 11942, Jordan
[b] Department of Mechanical Engineering, Al Zaytoonah University of Jordan, Amman 11733, Jordan

ARTICLE INFO

Article history:
Available online 5 June 2012

Keywords:
Bio fuels
Emulsified fuels
Oxygenated fuels
Soot formation

ABSTRACT

This work presents an experimental technique for the measurement of the soot formation in pure fuel, biofuel and emulsified fuel, that constitute this fuels was studied in heated shock tube and investigated the possibility of reducing soot production in locally refined diesel, locally produced biofuel and emulsified fuel. This reduction was conducted using certain oxygenated additives (methane, ethane and acetone). It was found that soot concentration is maximum when pure diesel was burned, followed by emulsified fuels and the lease concentration was obtained when biofuel was burned. Further, methanol has the most significant effect on the reduction of soot once added to each fuel, while acetone has the lease effect on soot reduction. The results gave good indication of the effect for oxygenated additives in reduction the soot formation.

© 2012 Elsevier Ltd. All rights reserved.

1. Introduction

It is known that soot "particulate matter" is a name given to the mixture of solid particles and liquid droplets found in air, the main constituents of this mixture is carbon. Soot is produced from many sources such as burning coal, diesel, wood, etc. Soot contains up to 40 different cancer-causing chemicals and can also cause respiratory and heart diseases. It is estimated to cause two million deaths in the developing world each year – mainly among children – when emitted from wood-burning stoves in poorly ventilated houses.

Black carbon, the component of soot that gives it its color, is thought to be the second largest cause of global warming after carbon dioxide. Formed through incomplete combustion of fossil fuels, wood and vegetation, it delivers a double whammy. This necessitates the reduction of soot emitted from any combustion system.

Alexiou et al. [1] studied the formation of soot during the pyrolysis of argon-diluted mixtures of toluene and *n*-heptane and of toluene and iso-octane in a reflected-shock tube. Soot induction times and rates of formation measured at 632.8 nm by laser beam attenuation showed an Arrhenius dependence on reflected-shock temperature.

Hinot et al. [5], performed experiments with two model soot aerosols brought into different forms of contact with Pt aerosol particles, to investigate the effectiveness of this contact in lowering the catalytic soot oxidation temperature. It was found that Pt-doped soot and simultaneously filtered aerosols were both equally effective in reducing the oxidation temperature by up to 140–250 °C for the spark discharge soot (with 3–47 wt.% Pt concentration in the soot cake), and by up to 140 °C for the pyrolysis soot (3 wt.% Pt).

Iuliis et al. [2] focused on the development and application of the laser extinction/scattering technique in shock tube experiments. Emphasis is given to the scattering optical arrangement for the determination of soot size growth. Results concerning the induction delay time, the soot yield and the particle diameter growth are presented for the pyrolysis of ethylene and toluene at pressure about 500 kPa and for a wide range of temperature.

Agafonov et al. [3] proposed a new detailed kinetic model of soot formation in shock tube pyrolysis and oxidation of aliphatic and aromatic hydrocarbons. The model is based on the comprehensive kinetic model of PAH formation and growth. The gas-phase kinetic scheme was validated against the experimentally measured concentration profiles of the main gas-phase species formed during toluene pyrolysis and H and OH radicals during benzene and phenol pyrolysis and toluene oxidation behind reflected shock waves.

Soot tendency (soot induction delay time and soot yield) of a diesel fuel surrogate and of the hydrocarbons that constitute this mixture was studied in a heated shock tube by Mathieu et al. [6]. The surrogate is composed of three hydrocarbons representative of major chemical families of diesel fuels (39% *n*-propylcyclohexane, 28% *n*-butylbenzene, and 33% 2,2,4,4,6,8,8-heptamethylnonane) in mass proportion. Their study of the diesel surrogate shows that the soot inception process does not depend on synergistic effects between hydrocarbons but seems to be initiated by the constituent of the surrogate that produces soot fastest, while other constituents were consumed later during the soot growth.

Hong et al. [4] investigated the influence of oxygenates on diesel soot emissions. Soot formation in fuel-rich *n*-heptane/oxygen

---

* Corresponding author. Tel.: +962 6 4291511; fax: +962 6 4291432.
E-mail address: engineering@zuj.edu.jo (M.A. Hamdan).

0196-8904/$ - see front matter © 2012 Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.enconman.2012.02.033

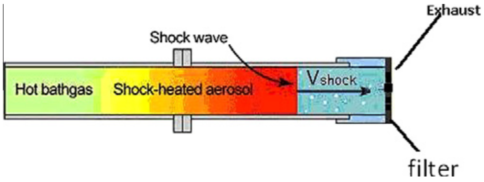

Fig. 1. The shock tube.

Table 1
Experimental matrix.

	Diesel	Biofuel	Emulsified fuel
No additive	Sample 1	Sample 5	Sample 9
Methanol	Sample 2	Sample 6	Sample 10
Ethanol	Sample 3	Sample 7	Sample 11
Acetone	Sample 4	Sample 8	Sample 12

mixtures with added dimethyl ether, acetone, butanol, or 3-pentanone was investigated behind reflected shock waves at pressures from 20 to 30 atm. and temperatures from 1600 to 1900 K. A significant reduction in the overall soot yield was found with the addition of small quantities of oxygenates as well.

This work investigates the possibility of reducing soot production from burning locally refined diesel, locally produced biofuel and emulsified fuel. This will be accomplished by the design, construction and testing of an experimental rig, which consists mainly of a shock tube, within which the combustible mixture is introduced and ignited and introduced to a customized filter. This filter is used to measure the concentration of soot that is produced during the burning of the fuel. Further. This investigation of soot reduction had been conducted using certain oxygenated additives, these additives contains sufficient amount of oxygen, which enhances the burning of carbon (soot) and hence soot reduction increases.

This research work aimed to reduce soot, which contributes significantly to environmental problem in Jordan and hence cleaner environment. The alternative fuels such as biofuels and emulsified fuels are of high competitive to diesel fuel, this will reduce the national energy bill.

2. Testing facility and measurements

Fig. 1 shows the shock tube used in this study. It is of circular in cross-section, and constructed of stainless steel, as shown it consists of two main chambers, which are separated by a diaphragm. One chamber contains the combustible mixture (drive section), upon ignition and due to high pressure this diaphragm suddenly bursts open under predetermined conditions to produce a wave.

The drive section with length 1600 mm and inner diameter of 38 mm and contain 4 holes, the first hole for pressure gauge, second hole for spark plug, third hole for thermocouple and the fourth hole for feeding gas. The driven section is of 1600 mm length and 38 mm inner diameter and it contains a customized filter at the end. Finally, both sections are linked by a flange coupling that contains the diaphragm.

After completing all necessary connections and verification, the liquid fuel was introduced into the tube and then heated up using an electrical heating tube such that the liquid fuel is evaporated. Then oxygen was introduced into the tube and ignition was obtained using a spark plug, consequently a flame is formed within the drive section and due to the low pressure in the driver section the diaphragm is raptured and a shock wave travels through the driver section. The filter in placed in the driven section where a visual check will give an indication of soot formation.

The above procedure was repeated for the three types of fuels with and without additives to each type of fuel.

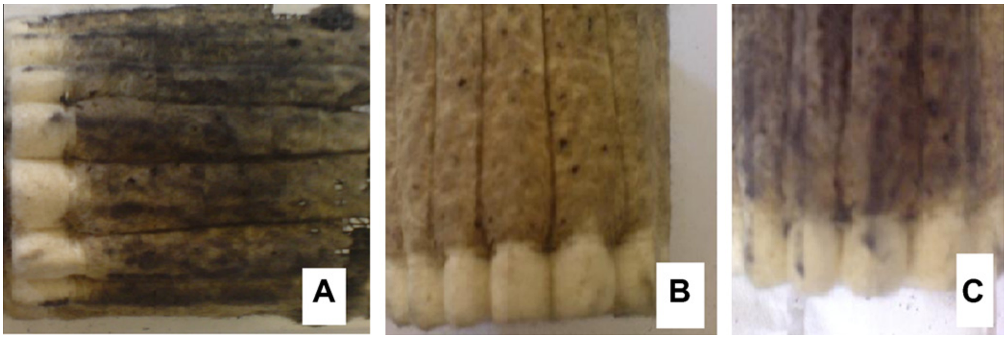

Fig. 2. Sample 1 (A: Diesel) vs. sample 5 (B: Biofuel) vs. sample 9 (C: Emulsified fuel).

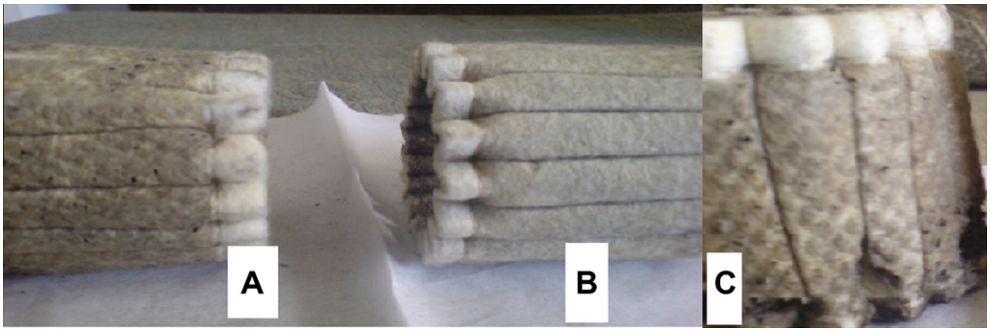

Fig. 3. Sample 2 (A: Diesel) vs. sample 6 (B: Biofuel) vs. sample 10 (C: Emulsified).

Download English Version:

https://daneshyari.com/en/article/761072

Download Persian Version:

https://daneshyari.com/article/761072

Daneshyari.com