Charcoal-Oil Mixture as an Alternative Fuel: A Preliminary Study

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Abstract: The fast depletion of fuel oil and continuous increase in the demand for power is a global issue. The world energy consumption is projected to grow at an average of 2.7-3.7% from 1996 to 2010. Therefore search for alternative fuel is highly prioritized. Thus this study presents the results on the characteristic of charcoal-oil mixture as an alternative fuel. The calorific value, ash content and stability of the mixture are determined.

Key words: Charcoal, fuel, palm oil, mixture

INTRODUCTION

Energy is one of the key factors in the development of a country. Over the years, the demand for energy will increase from industrialization, more transport required and also from growing population. To minimize problems on power shortages in the future. One of the option is to develop a non-conventional form of fuel that can be obtained through biomass and wood gasification, emulsification of liquid fuel, briquetting of solid waste and liquefaction or slurring of coal[1,2]. US patent 4201552 claimed that a coal-oil mixture was cheaper than oil, easier to handle, more combustible than coal and economical to store. However it was not cheaper than coal[3]. Presently, industrial power plants utilize liquid hydrocarbons as fuel because of their energy content and availability. On the other hand, many power plants utilized solid fuel such as coal since it is much less expensive than liquid fuels[3]. Attempts to utilize both types of fuel in admixture have not been successful because the dispersions obtained have not been sufficiently stable. Therefore, it would be highly desirable to provide coal-oil fuel slurries, which are stable in that the coal remains dispersed in the oil. The objective of this work is to produce charcoal-oil mixture from palm-based materials as an alternative fuel.

MATERIALS AND METHODS

Preparation of Charcoal-Oil Mixture (COM): The charcoal-oil slurry or dispersion was prepared by heating the oil to a temperature of 50°C and adding to stabilizer to the oil in the desired quantity based on weight. The charcoal was then added to the oil-stabilizer composition and the resultant composition was stirred vigorously, usually within 30 min, to ensure uniform mixing.

Physical and chemical properties determination: Viscosities of all fuels were determined at room temperature. A Brookfield viscometer (Brookfield Engineering Laboratories, Inc., Stougton, MA) with adapter was used. Gross energy content or heat of combustion of all fuel was determined according to ASTM method D240-92[5]. A LECO AC 350 automatic oxygen bomb calorimeter (LECO Corporation, Michigan, USA) was used.

The density of the fuel was determined using Metler Toledo Densitometer. The ash content was determined according to ASTM D482-46[4]. The shelf life and stability of the COM fuel were also considered. This was done by storing the fuel in a graduated cylinder and was closely monitored in a timely sequence.

RESULTS AND DISCUSSION

The results have shown that as the charcoal content increases, most of the COM fuel properties also increase (Table 1), but it was observed the calorific value decreases. The increasing COM fuel properties include ash content, density, viscosity, % sediment, shelf life and stability. The decrease in calorific value is due to the presence of excessive ash content and % sediment caused by the increase of charcoal.
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Table 1: Summary of fuel samples properties

| Fuel sample | Ash (%) | Density, g cm⁻³ | Calorific value, J g⁻¹ | Viscosity, % | Sed |
|-------------|---------|-----------------|------------------------|-------------|-----|
| Oil         | 0.02    | 0.8722          | 39787                  | 5.5         | -   |
| Charcoal    | 1.77    | ND              | 29209                  | ND          | -   |
| COM fuel    |         |                 |                        |             |     |
| 5 C         | 0.32    | 0.9076          | 39258                  | 6.9         | 22.92 |
| 10 C        | 0.46    | 0.9317          | 38966                  | 10.5        | 39.58 |
| 15 C        | 0.66    | 0.9479          | 38357                  | 14.5        | 58.70 |
| 20 C        | 0.87    | 0.9887          | 37889                  | ND          | 71.71 |

ND = Not determined; 5 C = 5% Charcoal; 10 C = 10% Charcoal; 15 C = 15% Charcoal; 20 C = 20% Charcoal

Table 2: Stability and flow properties of tested COM fuel

| Fuel sample w/o stabilizer | Time taken to drain column, min |
|---------------------------|---------------------------------|
| w/o Stabilizer | With stabilizer |
| 5C             | 77.08                          | 51.02                          |
| 10C            | 60.42                          | 22.45                          |
| 15C            | 41.32                          | 4.35                           |
| 20C            | 28.26                          | 4.00                           |

Table 3: Effect of surfactant concentration on the stability and heating value of COM fuel containing 5% charcoal

| Surfactant conc., % | Stability | Calorific value, J g⁻¹ |
|---------------------|-----------|------------------------|
| 0.0                 | 0.96      | 39365                  |
| 0.5                 | 0.36      | 39248                  |
| 1.0                 | 0.32      | 39199                  |
| 2.0                 | 0.20      | 38990                  |
| 3.0                 | 0.20      | 38963                  |

Stability = (Separated oil layer/total volume)

Table 4: Energy content of COM using various types of palm biomass

| Oil | EFB | Shell | Mesocarp |
|-----|-----|-------|----------|
| PD  | 41110 | 41050 | 40296 |
| CPO  | 39718 | 39123 | 38983 |
| RBDPO  | 39585 | 38975 | 39278 |
| PB  | 39788 | 39657 | 39512 |

PD = Petroleum diesel; CPO = Crude palm oil; RBDPO = Refined, bleached and deodorized palm oil; PB = Palm biodiesel; EFB = Empty fruit bunch

Plasticizing, stabilizing and emulsifying properties. Surfactants of different types such as anionic, nonionic and polymeric can be used to stabilize coal-oil mixture system.

The stability of COM fuel using various types of surfactant/stabilizer is shown in Fig. 1. The general pattern of the results showed that the stability decreases in the following order: polymeric > nonionic > cationic > anionic. Due to the availability of material, nonionic surfactant was chosen for further evaluation. The influence of the surfactant concentration on the stability, calorific value and pour point was also studied (Table 3). Adding surfactant up to 3% increased the stability of the system but did not show any difference in pour point of the fuel. Slightly decreased in calorific value was also observed with increasing of surfactant concentration.

In the second group of experiment, the energy content COM using various types of palm biomass was evaluated (Table 4). The gross energy content for COM containing palm oil and palm biodiesel as a liquid part
is lower than that of containing petroleum diesel. Georing et al.(7) reported that gross heat content of differently processed vegetable oils was less than that of petroleum diesel. COM fuel using empty fruit bunch as a solid part gave higher energy content than shell and mesocarp.

CONCLUSION
Charcoal-oil mixture can be produced from palm-based material. Adding stabilizer or using smaller particle size of charcoal can increase the stability of the slurry. The stability tends to increase with charcoal concentration.

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