Energy, exergy and economic analysis of a Diesel engine fueled with castor oil biodiesel

Farshad Meisami and Hossein Ajam

Abstract

Biodiesel is a renewable, clean-burning Diesel replacement. Biodiesel is made from vegetable oils or animal fats. It can be used as a fuel for vehicles in its pure form, but it is usually used as a Diesel additive to reduce exhaust emissions. Numerous studies have been performed on effects of various biodiesels on engine performance and emissions; however, in those studies, less attention has been paid to the availability (exergy) of engine processes. In this investigation, various biodiesel blends have been tested experimentally on a four-cylinder turbocharged Diesel engine. Engine energy, exergy and economic analysis have been performed using the experimental data. The results showed that the structural oxygen content of biodiesel improves the combustion efficiency. However, the engine's thermal efficiency decreases due to the lower heating value of the biodiesel. Also, destruction of exergy increases when using biodiesel. Among various biodiesel blends, the 15% biodiesel–Diesel blend shows an optimum condition. In this case, the engine power slightly decreases, and both the thermal efficiency and the exergetic efficiency increase. Also, the highest combustion efficiency was observed. The results of emissions economic analysis showed that all biodiesel blends were more affordable than Diesel fuel. The results of full economic analysis (emissions, fuel cost, fuel consumption and engine power loss) showed that only the 5% biodiesel–Diesel blend was more affordable compared to Diesel.

Keywords

Biodiesel, combustion, energy analysis, exergy analysis, economic analysis

Date received: 28 September 2014; accepted: 10 February 2015

Introduction

Nowadays, most of our energy demand is provided by fossil fuels. They are generally considered to be non-renewable resources. The use of fossil fuels raises serious environmental concerns. In order to resolve these problems, various solutions have been proposed by various investigators. Using biodiesel is one of the solutions that improve both of the mentioned concerns simultaneously. Biodiesel can be easily produced from different vegetable oils or animal fat. Numerous studies have been conducted on biodiesel production methods and its effect on engine performance and exhaust emissions, such as biodiesel manufactured from jatrofa,1 waste cooking oil,2 palm,3 cotton seed4 and animal fats.5 It has been frequently reported that emissions of CO, HC, soot and particulate matter (PM) reduce when using biodiesel.6,7 They reported an inverse trend in NOx emissions.8 Biodiesel and its blends exhibit a slight reduction in the engine power, compared to Diesel fuel.9 Biodiesel contains about 10% oxygen in its structure.10 So, this higher oxygen content also leads to lower heating values (LHVs), which may result in engine power losses and the increase in specific fuel consumption.11 However, there are some investigations reporting that the power output increases when using biodiesel.12 They described this increase with the increased cetane number, but a high value of biodiesel viscosity could also be another reason. Enweremadu and Rutto13 collected and analyzed the published articles about engine combustion, performance and emissions while using biodiesel blends as fuel.

All these studies were based on the first law of thermodynamics (energy analysis). The thermodynamics...