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Technical note

Study on cottonseed oil as a partial substitute for diesel oil in fuel for single-cylinder diesel engine

Y. He*, Y.D. Bao

College of Biosystems Engineering and Food Science, Zhejiang University, Hangzhou 310029, China

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Abstract

The experiments were undertaken to obtain the knowledge necessary for raising the thermal efficiency of mixed oil composed of cottonseed oil and conventional diesel oil and for improving the performance of engine fuelled by the mixture. The experimental results obtained showed that a mixing ratio of 30% cottonseed oil and 70% diesel oil was practically optimal in ensuring relatively high thermal efficiency of engine, as well as homogeneity and stability of the oil mixture. A quadratic regressive orthogonal design test method was adopted in the experiment designed to examine the relationship between specific fuel consumption and four adjustable working parameters (intake-valve-closing angle (α), exhaust-valve-opening angle (β), fuel-delivery angle (θ) and injection pressure (P, in 10^4 Pa)) when the above-mentioned oil mixture was used. The mathematical equations characterizing the relationship were formulated. The equation of specific fuel consumption derived from the regressive test under each operating condition was set as the objective function and the ranges for the four adjustable working parameters were the given constraint condition. Models of non-linear programming were then constructed. Computer-aided optimization of the working parameters for 30:70 cottonseed oil/diesel oil mixed fuel was achieved. It was concluded that the predominant factor affecting the specific fuel consumption was fuel-delivery angle θ, the approximate optimal value of which, in this specific case, was 3–5° in advance of that for engine fuelled by pure diesel oil. The experimental results also provided useful reference material for selection of the most preferable combination of working parameters.

Keywords: Alternative fuel; Diesel engine; Cottonseed oil

* Corresponding author. Tel.: +86-571-869-711-43; fax: +86 571 869 711 43.
E-mail address: yhe@zju.edu.cn (Y. He).

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1. Introduction

With the rapid development of rural agricultural production and rapid growth of local industry in China, the discrepancy between demand for and supply of energy has become an increasingly acute problem. Due to seasonality of farm work, a temporary shortage of fuel will bring about unexpected and irreparable loss to peasants. In the cotton-planted areas, cottonseed oil is a by-product of cotton and seldom used as cooking oil, it is possible to use cottonseed oil as an emergency auxiliary or endemic fuel of diesel engine [1–4].

China is rich in cottonseed and research on using cottonseed oil as diesel engine fuel has been intensively and widely studied here [5,6]. From a technological point of view, the fuel property of cottonseed oil seems to meet the fundamental requirements of diesel engine [6,7]. Therefore, use of cottonseed oil blended with diesel oil as a substitute for conventional diesel oil in diesel engine is reasonable and prospective. For this purpose, a modification of diesel engine structure is unnecessary, as has been confirmed by the literature [5–7]. However, there are certain differences between cottonseed oil and diesel oil, such as differences in spraying characteristics and combustibility [2,4], which require attention. The oil mixture will not achieve the optimum of combustion and, accordingly, sufficiently smooth engine performance, effective power utilization and economically adequate reward, unless relevant working parameters are readjusted in accordance with results of carefully designed experimentation [6,7].

2. Objective

The objective of this study is to procure the most desirable values for the relevant working parameters and their optimal combination based on the experiments with mixture fuel composed of cottonseed oil and conventional diesel oil (Table 1).

3. Materials and methods

3.1. Fuel properties

Both No. 0 diesel oil and cottonseed oil purchased from the market were selected for performance test on the engine.

Table 1
Parameter of diesel fuel and cottonseed oil

Parameter	Diesel fuel	Cottonseed oil
Relative density	0.840	0.915
Viscosity (P)	0.048	0.625
Net calorific value (MJ/kg)	42.52	39.47
Density (g/dm^3)	815	874