

Development of process control for small scale biodiesel production plant

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Abstract

Biodiesel is gaining more and more importance as an attractive fuel due to the depleting nature of fossil fuel resources. The transesterification is the process of removing the glycerides and combining oil esters of vegetable oil with alcohol.

This paper is about the development of a novel process control of the small scale biodiesel production. The method shown in this article is a feasible solution to eliminate the drawback of unequal quality produced by the small scale production technology.

Keywords

renewable energy, small scale biodiesel production, process control, transesterification

1. Introduction

Biodiesel is a fatty acid alkyl ester derived from the transesterification of vegetable oil and is considered as a renewable fuel that can be substituted for traditional diesel. Nearly all diesel-powered equipment can use up to 20 % biodiesel and many engines can use blends or even pure biodiesel with little or no modification. Moreover, emissions of greenhouse gases, carbon, monoxide and particulates can all be significantly reduced.

Researchers and scientists had developed different methods for biodiesel production from different bio fuels. Most of the researchers/ scientists reported that the production of biodiesel was more when the process was used a catalyst.

Ahn et al. (1995) followed a two-step reaction process to produce biodiesel. Using this method canola methyl ester (CME), rapeseed methyl ester (RME), linseed methyl ester (LME), beef tallow ester (BTE) and sunflower methyl ester (SME), synthesized in a batch reactor using sodium hydroxide, potassium hydroxide and sodium methoxide as catalysts. Cvengro and Povaz (1996) described biodiesel production by using two-stage low-temperature transesterification of cold pressed rapeseed oil with methanol at temperatures up to 70 °C. A new enzymatic method of synthesizing methyl esters from plant oil and methanol in a solvent-free reaction system was developed by Masaru et al. (1999). In the same year, Uosukainen et al. (1999) presented statistical and experimental

design to evaluate interdependence of process variables in enzymatic transesterification. The authors also studied the alcoholysis of rapeseed oil methyl ester (biodiesel). Fangrui and Hanna (1999) had reviewed the biodiesel production. Samukawa et al. (2000) investigated the effects of the pretreatment of immobilized *Candida antarctica* lipase enzyme (Novozym 435) on methanolysis for biodiesel fuel production from soybean. Ikwuagwu et al. (2000) discussed the production of biodiesel using rubber seed oil. The effect of three principal variables namely molar ratio of methanol to oil, amount of catalyst and reaction temperature on the yield of acid-catalyzed production of methyl ester (biodiesel) from crude palm oil had been studied by Crabbe et al. (2001).

Waste frying oils transesterification was studied by Felizardo et al. (2006) with the purpose of achieving the best conditions for biodiesel production. In the same year, Miao and Wu (2006) introduced an integrated method for the production of biodiesel from microalgal oil. Zhu et al. (2006) produced biodiesel from *Jatropha curcas* oil using a heterogeneous solid super base catalyst (calcium oxide). Meher et al. (2006) reviewed the technical aspects of biodiesel production by transesterification. Al-Zuhair et al. (2006) discussed the effect of fatty acid concentration and water content on the production of biodiesel. Xue et al. (2006) had developed a new method for preparing raw material for biodiesel. Production of fatty acid methyl esters from crude tobacco seed oil (TSO) having high free fatty acids (FFA) was investigated by Veljkovic' et al. (2006). Royon et al. (2007) studied the enzymatic production of biodiesel by methanolysis of cottonseed oil. A two-phase membrane reactor had developed to produce biodiesel from canola oil by Dube' et al. (2007). Exergy Flow Analysis (ExFA) is applied to the process of biodiesel production by Talens et al. (2007). Production of fatty acid methyl ester from palm fatty acid distillate (PFAD) having high free fatty acids was investigated by Chongkhong et al. (2007). Response surface methodology (RSM) based on central composite rotatable design (CCRD) was used to optimize the three important reaction variables namely methanol quantity, acid concentration and reaction time for reduction of free fatty acid content of the oil to around 1% by Tiwari et al. (2007). Rathore and Giridhar (2007) investigated synthesis of biodiesel from edible oils like palm oil and groundnut oil and from crude non-edible oils like *Pongamia pinnata* and *Jatropha curcas* in supercritical methanol and ethanol without using any catalyst from 200 oC to 400 oC at 200 bar. Demirbas (2008) studied a non-catalytic biodiesel production with supercritical methanol, which allows a simple process and high yield because of the simultaneous transesterification of triglycerides and methyl esterification of fatty acids. Non-catalytic biodiesel production technologies from oils/fats in plants and animals developed by Imahara et al. (2008) employing supercritical methanol.

2. Objectives of the study

The overall objective of this study is to identify the technology properly applies in a small scale biodiesel production plant and results a uniform quality end

product as a result of the production. The biodiesel produced should be in conformity with the EU standards EN 14214.

3. Biodiesel production

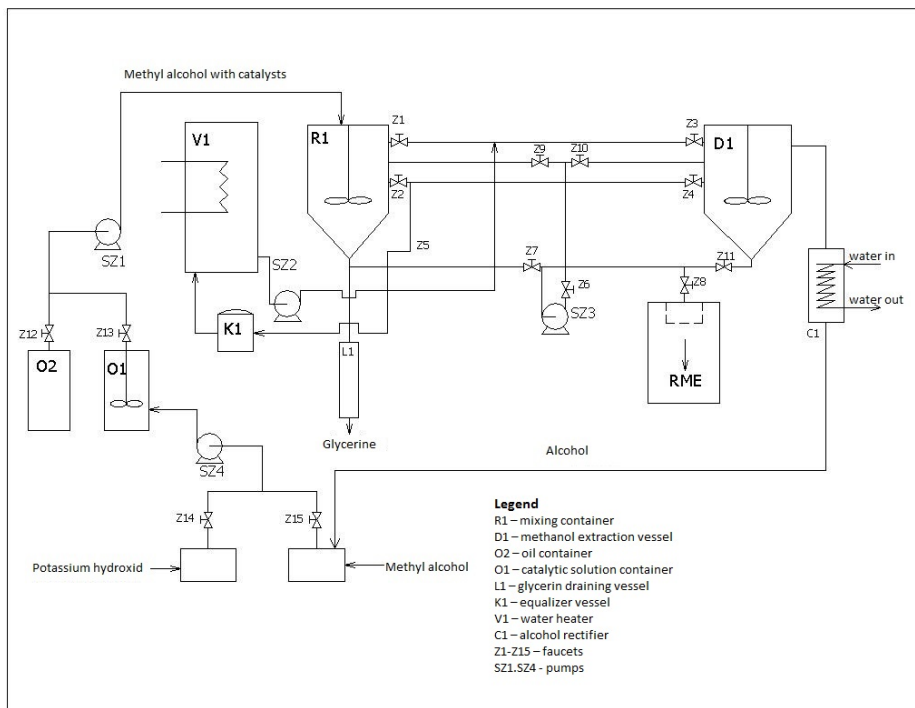


Figure 1. Small scale production technology design



Figure 2. Small scale biodiesel production model

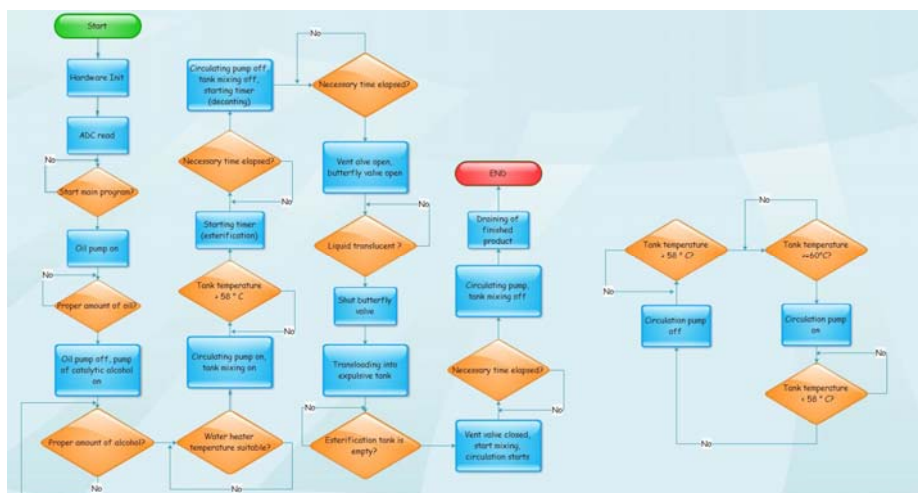


Figure 3. Logical operation of biodiesel technology

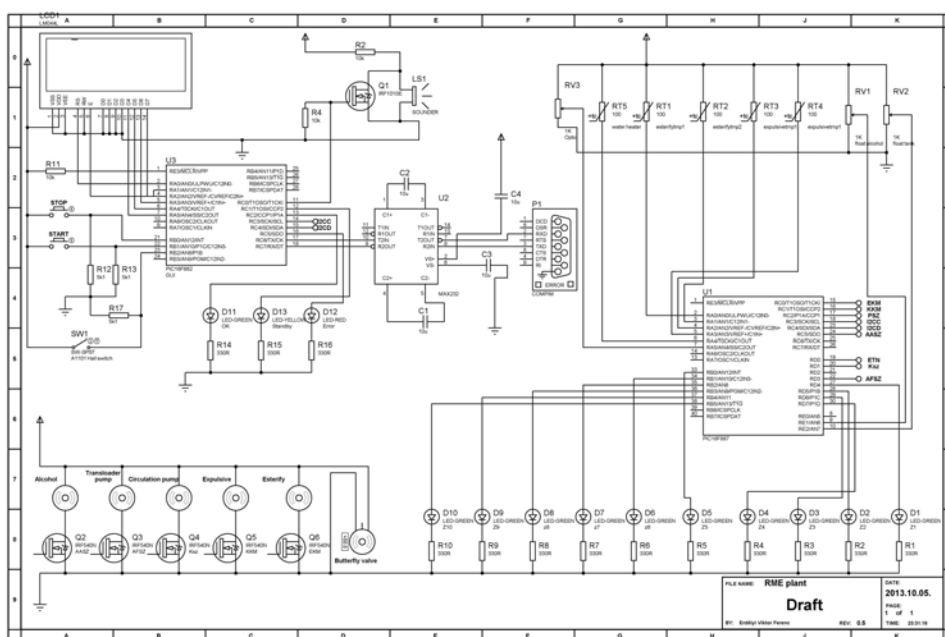


Figure 4. Digital circuit of automatic control of biodiesel production technology model

Biodiesel production is based on trans-esterification of vegetable oils and fats through the addition of methanol (or other alcohols) and a catalyst, giving glycerol as a co-product. Feedstock includes rapeseeds, sunflower seeds, soy seeds and palm oil seeds from which the oil is extracted chemically or mechanically. Advanced processes include the replacement of methanol of fossil

origin, by bioethanol to produce fatty acid ethyl ester instead of fatty acid in order to expand the relatively small resource base of biodiesel, new processes have been developed to use recycled cooking oils and animal fats though these are limited in volume. Hydrogenation of oils and fats is a new process that is entering the market. It can produce a biodiesel that can be blended with fossil diesel up to 50% without any engine modifications. Synthetic biofuel production via biomass gasification and catalytic conversion to liquid using Fischer-Tropsch process (biomass conversion to liquids BTL) offers a variety of potential biofuel production processes that may be suited to current and future engine technologies. The largest biodiesel producer is Germany, which accounts for 50% of global production. Biodiesel is currently most often used in 5%-20% blends (B5, B20) with conventional diesel, or even in pure B100 form.

Results and conclusions

Many previous projects were conducted before this automation setup. These days the small scale biodiesel production technology is already clear and well known. The experts have a lot of experiences on the details of the technology. At the same time many different raw materials are suitable for producing biodiesel fuel. The different inputs have different chemical and physical features while we need levelly the same fuel quality because the fossil diesel fuel could be substituted only this way.

To produce a well balanced and constant quality of biodiesel fuel the ability of controlling every step of the production technology is highly required. In case the technology is controllable independently of the quality of the input material the standardized quality of output is insurable. This goal is fulfilled by the control system shown in this paper.

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