NEW EUROPEAN BIOFUELS FOR DIESEL ENGINES

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Abstract

The World is strongly dependent on crude oil for its transport needs. In order to diminish this dependence, we need to introduce clean, CO_2-efficient, secure and affordable transportation fuels. The development of innovative biofuel technologies will help to cover significantly (up to 25% in Europe) road transport fuel needs. Biofuels production of 33 billion litres in 2004 is small compared to 1200 billion litres of gasoline produced annually worldwide. The current production of liquid biofuels in the EU 25 is about 2 Mtoe, which is less than 1% of the market. Recent assessments have concluded that the 2010 targets, 18 Mtoe used in the transport sector, are unlikely to be achieved. There can be three basic possibilities of accomplishing this target: i) use of alcohols (first of all ethanol) and their mixing with petrol; ii) use of fatty acids esters (methyl or ethyl) of vegetable oils and their mixing with diesel fuel, iii) use of synthetic hydrocarbons of the synthetic gas coming from biomass resources and eventually their mixing with other ,,classical" hydrocarbons.

This paper presents a novel way of utilizing alcohols as fuels for a diesel engine. It is proposed to use heavy alcohols as a mix with conventional diesel fuel. The possibility to use a mix of butanol (as heavy alcohol) with conventional diesel fuel is demonstrated. Butanol has some key advantages over ethanol and light hydrocarbons (petrol), including higher energy content and better transport characteristics. Moreover, butanol is hydrophobic, so a new logistic infrastructure is not necessary. This paper demonstrates that a diesel-butanol fuel mixture is supplied to a diesel engine without any problems. A consumption of proposed biofuel mixture from +35% to -35% of typical diesel fuel depends on many factors not only on fuel energy density.

A near-term effort of BP Biofuels and DuPont to develop and commercialize biobutanol is well-known. Here, it is proposed a new technological process combining electricity generation in fuel cells with electrolysis and a production of butanol from ethanol which gives an opportunity to reduce today's over production of ethanol without a necessary change of existing infrastructure.

Keywords: *transport, combustion engines, alternative fuels, biofuels, butanol*

1. Introduction

The increase of prices of fossil fuels (especially nowadays) one the one hand and the environment demand on other hand lead to the conclusion that the introduction of biofuels is necessary. This situation exists not from today [1-2]. Nowadays it is only clearer to see. Thus the requirement of the European Union: that:

- till year 2020:
- the energy consumption has to be lowered about 20%, and
- 20% fuel has to come from renewable natural resources (in a case of engine fuels it will be 10%), are fully comprehensible and must be fulfilled. The question is only how?

Biofuels that exist in the market or are in the phase of investigations are:

- alcohols (first of all ethanol),
- vegetable oils and from these oils fatty acid (methyl or ethyl) esters,
- synthetic hydrocarbons (from the synthesis gas coming from the biomass).

Alcohols have the biggest chance to be engine fuel (and further synthetic hydrocarbons from the biomass). Vegetable oils can be only (demanded) ingredients to the engine fuels because of

agricultural limits (we have too small areas to grow oil plants). Opposite to them the obtaining of alcohols has very rich sources (not only biomass directly but the organic part of communal waste or settings of waste water for example).

The world wide hope is connected with the use of ethanol as a biofuel and this is the case especially in Europe. The reason for this is comprehensible:

- in every European country technologies of production of ethanol from biomass are well-known,
- in every European country there is overproduction of ethanol,
- in every European country there is overproduction of biomass,
- in every European country there is the excess of wastes which can be used to the production of the ethanol,
- every European country imports liquid fuels excessively - especially engine fuels,
- every European country has the unemployment problem.

But ethanol is not good as an engine fuel. There is an idea of using of ethanol in specially adapted spark ignition engines with low efficiency e.g. in Brazil or Sweden or in special diesel engines (in this case with higher efficiency) in Europe, like a SCANIA diesel engine.

Ethanol as a fuel ingredient has a limited application, and it can be mixed only with petrol or in small amount with diesel fuel.

2. Problems

In Europe (and worldwide) there is overproduction of biomass and overproduction of light alcohols especially ethanol. That is the best confirmation of the fact that ethanol is not acceptable fuel. The mixing of ethanol with hydrocarbon fuels is very problematic. Ethanol is hydrofiling what changes its properties. Energy content in ethanol is half of energy content in petrol. Spark ignition engines where ethanol can be used as fuel are of lower efficiency than diesel engines, etc.

A main problem with an introduction of ethanol is that ethanol can be mixed only with petrol. In other case ethanol can be used as fuel only in the special engines, but these engines are not in use in Europe. However, more and more diesel engines are used in Europe today. Therefore ethanol cannot be practically used in engines that are not in exploitation today.

The situation is that ethanol from today's overproduction can be used nowadays only as an ingredient to petrol which is today in overproduction, too. In another case all engines existing today in exploitation must by changed. That is technically possible but it needs time, money and efforts. All this makes no sense because it is not necessary.

3. Problem solution

The problem will be solved in case of introduction to exploitation of fluids coming from biomass, compatible with conventional or synthetic hydrocarbons. One of these fluids is heavy alcohols (which contain more than 2 atoms of carbon in the molecule). Especially the butanol [3] is good here.

The properties of the butanol as engine fuel or an engine fuel ingredient are very good - opposite to ethanol [3-4]. All these problems that come from ethanol introduction as an engine fuel do not exist with butanol.

Energy content of butanol is almost the same as petrol. Butanol mixes well (in any proportion) with all hydrocarbon fuels especially with diesel fuel. Butanol is hydrophobic so the properties of fuel do not change for a long time. Hydrocarbon mix with butanol (or butanol itself) can be used in today's existing engines.

Very important is that ethanol from today's overproduction can be transformed into butanol.

Butanol can be produced from feedstock coming from renewable sources. In this case butanol is named biobutanol.

Biobutanol can be produced in the two main technological paths.

We have to produce of biobutanol from biomass directly. In this case biobutanol can be produced by fermentation of biomass in the A.B.E. process. The process uses the bacterium *Clostridium acetobutylicum*. (in the past such new bacteria were discovered for production of butanol). Difference in ethanol production is primarily in fermentation of feedstock - producing butanol rather than ethanol causes fermentation and does not change distillation. Feedstocks are the same as for ethanol - energy crops such as sugar beetroots, sugar cane, corn grain, wheat and cassava as well as such as straw and corn stalks.

According to DuPont existing bioethanol plants cost of change to the biobutanol production can be retrofitted.

However the analysis of this possibility of biobutanol production shows that nowadays technologies are not effective. During production a lot of byproducts (for example acetone) are formed so that the obtaining of biobutanol from biomass is relatively low. Production process is by this complicated and not friendly for environment. Situation can be changed in case of introduction of new bacteria first from all genetically modified ones. Of course introduction of this process needs new infrastructure expenses.

Not without meaning is the fact that existing infrastructure for the ethanol production would not be used. The overproduction of ethanol from existing plants also would not be used too.

Another path to biobutanol production is electrolysis of (bio) ethanol.

The electrolysis goes according to the chemical equation:

$$2C_2H_5OH + 2C_2H_5OH \rightarrow 2C_4H_9OH + 2H_2 + O_2$$

This possibility of biobutanol forming is the most effective today. Technology of ethanol production is worldwide known and is relatively simple.

Synthesis of butanol from ethanol in electrolysis process is possible but relatively not much recognized. It must be carefully researched.

Introduction of new fuel needs carrying out of investigations in two main groups of topics:

- creation (and optimization) of manufacturing process of conversion of ethanol to butanol, particularly by low energy consumption,
- use of butanol as fuel first of all as diesel fuel ingredient and its impact on durability, reliability, efficiency and emissions of engines.

A new designed plant to conversion of ethanol to butanol is proposed, where electrolysis process is directly connected with fuel cell.

Generally plant concept is showing on the Fig. 1.

Electrical energy needed to the electrolysis process comes from the fuel cell. And the byproducts of ethanol electrolysis (that is hydrogen and oxygen) are led to the fuel cell where electrical energy is now produced. So with conversion of ethanol to butanol only energy to cover all electrical losses is needed. This solution permits butanol production with very low energy consumption. External energy can come from removable sources like solar energy (wind or water energy, too).

New fuel must be introduced in all transport with use petrol and first on all diesel fuel.

The first results of investigations are showing on the Fig. 2.

On the Fig. 3 is showing the difference (in percent) in specific fuel consumption a new fuel to diesel fuel.

In the both last figures are showing different in specifically fuel consumption of new fuels depend to specifically consumption of standard diesel (EN 590) fuel. Different changes from point to point on the universal profile of engine. The same above ESC test phase. The different should be going to 65% by idle speed of engine and to 35% in other points of engine profile. Generally different is greater the higher is alcohol content in fuel. Interesting is that in some points of engine profile specific fuel consumption by new fuels is less then by conventional diesel fuel. All this goes to show that parallel to introduction of new fuels must by changed control of the fuel

injection systems of engines (in case of showing investigations the injections system parameters are not changed).

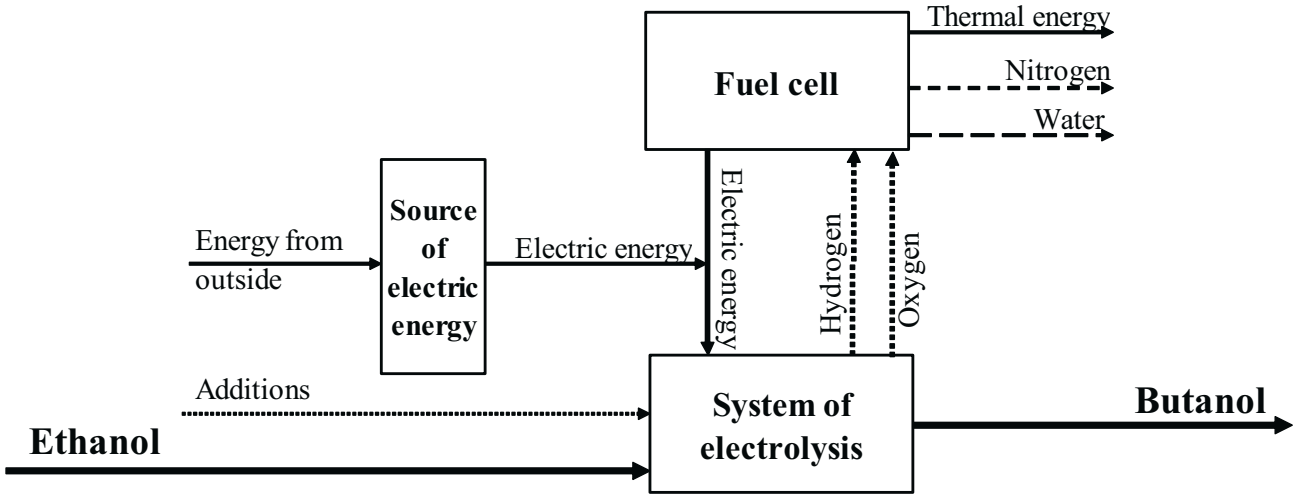

Fig. 1. Plant concept to obtain butanol from ethanol

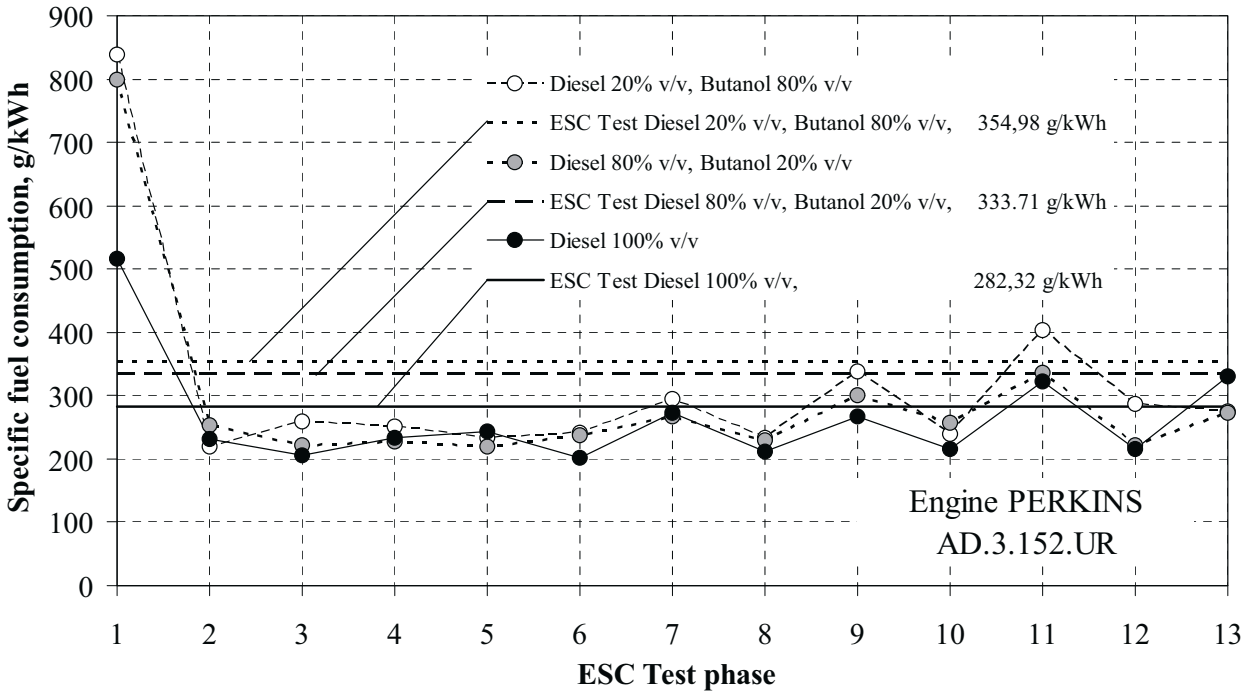

Fig. 2. Investigations results of ESC test for a diesel engine

4. Conclusion

Increase of prices of fossil fuels for one hand and environment demand for other hand lead to require introduction of biofuels. Nowadays it is clear to see. Generally is to today the are possible on tree ways; use alcohols (first of all ethanol) and his mix with petrol, use of vegetable oils and from these oils fatty acid (methyl or ethyl) esters and his mix with diesel, use synthetic hydrocarbons (from the synthesis gas coming from the biomass) and eventually his mixing with other „classical" hydrocarbons.

In present work is present another way to use alcohols. Namely use heavy alcohols as a mix with conventional diesel fuel. As an example this possibility is shown by use as fuel a mix of butanol (as a heavy alcohol in this case) with conventional diesel fuel. It is to affirm that is possible to create of mix of both ingredients in any proportions.

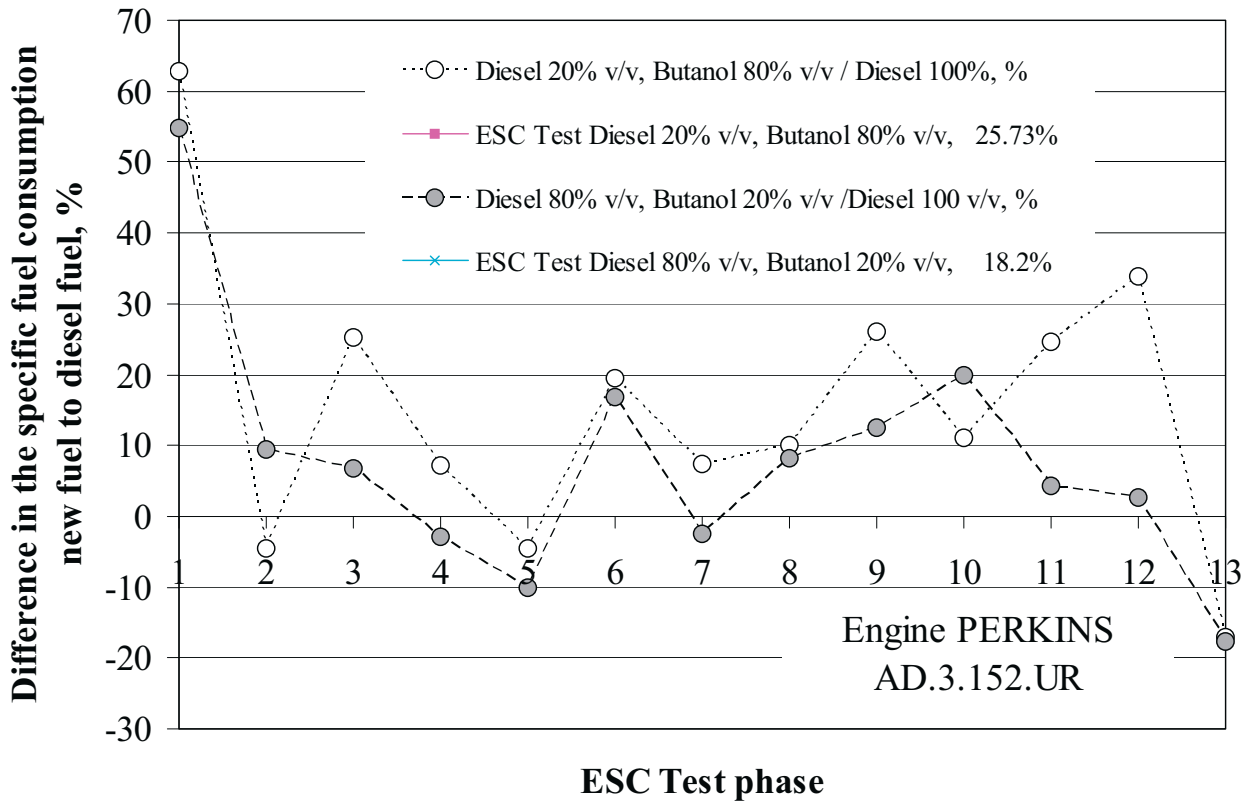

Fig. 3. Difference of the specific fuel consumption for new fuel to diesel fuel

Butanol has very good properties as a fuel. First of all energy contents in butanol is similar to energy contents in light hydrocarbons - petrol for example. Butanol is hydrophobic, so is a very good for logistics (it is not necessary a new infrastructure to provide of fuel).

As mix with diesel fuel is butanol very usual. Engine worked with butanol diesel mix supplying without any problems. Generally it can be assumed that specifically fuel consumption to be in increase with butanol share in fuel mix. But this is depending of many factors not only from energy density of fuel mix. The first investigations showed that. The specifically fuel consumption changes from plus 35% more than by diesel fuel to minus 35% les then diesel fuel consumption. This is difference to other biofuels. By rapes methyl ester, for example, specifically fuel consumption is higher in all point of engine profile.

Produce of butanol is known. It will be interesting to use for production an electrolysis process especially in new plant that electrolysis process is connected with process to get electrical energy from byproducts of electrolysis (i.e. hydrogen and oxygen) in fuel cell. It's shown to be more efficient.

The possibility to go of butanol from ethanol give a very good perspective for use an ethanol from today's over production and that without essential change of infrastructure.

All this lead to conclusion that to come up to expected of European Union is full possible.

References

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