On possible supplying ship diesel engines with alternative fuels (mixtures of diesel oils and vegetable oils or their esters)

Preliminary report

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ABSTRACT

The paper presents introduction to the research on possible supplying ship diesel engines with mixtures of diesel oils and vegetable oils or their esters with accounting for ecological aspects, i.e. exahust gas purity. Characterisitics of vegetable oils and their esters are compared with those of diesel oils; some consequences of their application to diesel engines, mainly for their working process and exhaust gas content, are indicated. Also, influence of combusting their mixtures with diesel oils are discussed in the same context. Scope of the planned research project is shortly presented.

Key words : ship diesel engines, alternative fuel oils, ecology

INTRODUCTION

Contemporary main diesel engines of sea-going ships are commonly supplied with heavy oil fuels. This very often concerns also auxiliary engines, especially electric generating sets.

However on many ships the electric generating sets are still fed with marine diesel oils (**MDO**). Also, most of diesel engines installed on small ships are run on **MDO**.

Permanently increasing demand of diesel oils (**DO**), increase of their prices, increasing ecological requirements make that more and more attention is paid to the alternative fuels called also substitute, renewable or unconventional. Another reason of the growing interest to the fuels is the increasing probability of dropping worldwide output of crude oil due to different causes. Moreover the problem of the hazard to natural environment, associated with mining, transport, processing and combusting the oil products is today brought up more and more strongly.

All energy sources other than crude oil products may be deemed unconventional ones [1]. As it results from the diagram presented in Fig.1. there is a wide range of possible media for supplying diesel engines. However today most of the unconventional fuels are not used in practice of operation of diesel engines, including ship engines.

In the research project planned by these authors the supplying of a ship diesel engine only with a mixture of marine diesel oil (**MDO**) and rape-feed oil methyl ester (**RME**) has been accounted for.

Application of vegetable oils for supplying diesel engines

In the northern zone of moderate climate rape oil, flaxseed oil and corn oil are mostly taken into account. In other climatic zones it can be soybean, sunflower, palm, cotton, sesame, peanut or coconut oil.

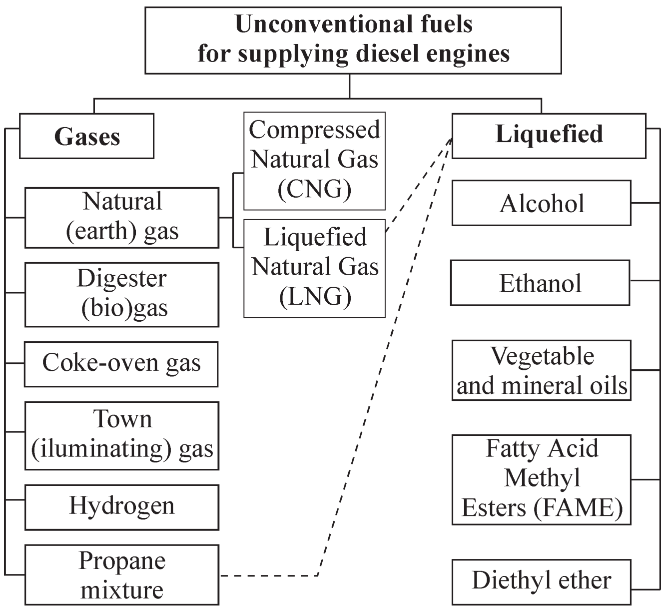

Fig. 1. *Scope of unconventional fuels for supplying diesel engines [1]*

Vegetable oils are esters of glycerol and fatty acids containing from 14 to 22 carbon atoms [5]. In Tab.1 [1] some properties of diesel oils and selected vagetable oils are compared.

It can be observed that some parameters of vegetable oils, their esters and diesel oils are of similar values, respectively. However their density, kinematic viscosity and flow temperature values much differ from those of diesel oils.

As far as rape oils are concerned (most interesting in case of Poland) their density and viscosity is distinctly higher, which can make supplying diesel engines with them difficult, however their positive features are: practically no sulphur content and bio-degradation ability. Their calorific value is smaller than

*Tab. 1. Comparison of some properties of diesel oils, vegetable oils and methyl esters of higher fatty acids of rape oil (**RME**)*

Parameter	Unit	Diesel oils (DO)	Vegetable oils (VO)		Esters
			rape oil (RO)	palm oil (PO)	(RME)
Density at 15°C	kg/m^3	820 ÷ 860	920	899	860 ÷ 900
Kinematic viscosity at : 40°C 100°C	mm^2/s	1.5 ÷ 4.5 0.75	30.0 ÷ 43.0 8.0 ÷ 8.4	39.3 8.4	4.3 ÷ 6.3 ~ 1.8
Cetane number		45 ÷ 55	~ 51	~ 51	49 ÷ 56
Gross calorific value	MJ/kg	42 ÷ 45	37.1 ÷ 37.5	37.3	37 ÷ 39
Flow temperature	°C	< -15	- 6	38	- 5 ÷ - 8
C/H/O ratio	% masy	86/14/0	77/12/11	77/12/11	-
Sulphur content	mg/kg	< 350	1	< 1	10 ÷ 25

that of diesel oils, due to different chemical content. Results of research on application of vegetable oils for supplying diesel engines [2, 3, 4, 9, 10] show worse cylinder filling, worse spraying, greater lengths of injected oil jets, associated with their large viscosity and density. Engines supplied with rape oil operate with a lower total efficiency mainly due to its lower calorific value in comparison with that of diesel oils, as well as due to worse spraying process resulting in a longer combustion. There is no unambiguous results of research on exhaust gas toxicity. Most obtained data indicate an improvement of exhaust gas purity relative to its content in the case of supplying engines with diesel oil. However the phenomena associated with supplying diesel engines with rape oil are disturbing, namely :

★ often occurence of clogging sprayer nozzles
★ great susceptibility to forming carbon deposits on piston heads, ring grooves, valves and valve seats
★ troubles with starting engines at low ambient temperatures
★ seizing precise pairs of injection pumps.

For these reasons it seems not advisable to commonly use vegetable oils as fuels for diesel engines. However much better effects can be obtained by applying chemically modified oils, i.e. methyl esters of higher fatty acids (**FAME**), see Fig.1. In Poland and many other European countries rape oil and methyl alcohol are usually applied to produce the esters called rape-feed oil methyl esters (**RME**).

Mixtures of diesel oils and vegetable oils or their esters

Due to substantial difficulties in applying only vegetable oils as well as due to limitation in using esters for running diesel engines, an alternative is to use mixtures of diesel oils and vegetable oils or diesel oils and vegetable oil esters. Properties of such mixtures depend on properties of their components and their content in a mixture. In this way it is expected to decrease density and viscosity of a mixture relative to those of a given vegetable oil or ester.

According to [1 , 10] 20% addition of diesel oil to rape oil made its viscosity dropping by 30% as well as ignition lag period lowering; engine starting features appeared improved. In common operational applications small additions of rape oil or **RME** to diesel oil (e.g. 5% to 20%) are usually reported. Tests on mechanical vehicles running on a 20% **RO** / 80% **DO** mixture did not reveal any detrimental consequences [10].

Therefore these authors have decided to carry out investigations on diesel engines supplied with **MDO**/**RME** mixtures initially containing no more than 10% of **RME**.

The basic properties of the **MDO** and **RME** and their mixtures selected for the experiments are given in Tab.2.

Preparation of such mixture is easy as it does not reveal a tendency to separation. However such mixtures could be less ressistant to ageing process hence their should be consumed in a short time.

*Tab. 2. The basic properties of the **MDO** and **RME** and their mixtures selected for the experimental tests*

Oils	Density	Viscosity				Viscosity			
	kg/m^3	°E				cST (mm^2/s)			
		20°C	50°C	70°C	80°C	20°C	50°C	70°C	80°C
Fuel oil (**MDO**)	831	1.31	1.11	1.04	1.01	4.2	2.1	1.4	1.1
Rape oil methyl ester (**RME**)	883	1.79	1.29	1.13	1.12	9.3	4.0	2.3	2.2
95% **MDO** + + 5% **RME**	833	1.38	1.15	1.08	1.01	4.7	2.5	1.8	1.1
85% **MDO** + + 10% **RME**	836	1.38	1.14	1.06	1.03	4.9	2.4	1.6	1.3

SCOPE OF THE PLANNED RESEARCH PROJECT

The planned research project is aimed at revealing :

✦ the influence of using **MDO**/**RME** mixture to running a ship diesel engine on its operation
✦ other possible problems arising from using such fuel mixture, e.g. its durability, storage conditions, transport, filtration processes etc.

The investigations will be carried out with the use of the L22 diesel engine installed in the laboratory of ship combustion engines, Gdynia Maritime University. The laboratory engine and test stand to be used were described in [6, 7, 8].

The planned tests will have a comparative character.The first series of all the tests will be devoted to the investigations of the engine fed with pure marine diesel oil, results of which will be taken as model ones. The consecutive test series will be carried out with **MDO**/**RME** mixtures of various content, and the controlled parameters such as engine speed or load will be changed in the same way as in the model series. Both absolute and relative values of the parameters will be analyzed.

The largest group of ship diesel engines working on diesel oil are those driving electric generating sets, which, due to their function, are of constant speed and highly changeable load (torque or fuel oil charge). Therefore the first tests will be performed for such loading mode of the engine. At different but constant engine speed values the engine load will be changed within the range from 20% to 80% of the rated torque, during which all important parameters of the engine working process as well as indication diagrams will be recorded. During the tests special attention will be paid to exhaust gas content both from the point of view of engine working process course and noxious component content.

In the first phase of the research the use of two fuels (of 5% and 10% of RME content in **MDO**/**RME** mixture) is assumed because in the case no changes in the engine's construction or regulation system are necessary.

The next phase of the research should be focused on durability (reliability) of the engine installed on a ship. However decision on initiating such tests will be taken on the basis of analysis of the results obtained in the first phase of the research.

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Conference

EXPLO-SHIP 2004

On 31 May and 1 June 2004 3rd International Scientific Technical Conference on :

Operational Problems of Floating Objects and Port Facilities

was held in Świnoujście, a Baltic coast port and health resort.

It was organized by Sea Navigation Institute, Maritime University of Szczecin.

During its scientific part 124 papers including the following 5 plenary ones, were presented :

★ *Coordinate systems applied to navigation over limited water regions* – by S. Gucma (Maritime University of Szczecin
★ *Some proposals on an unified maritime safety and security system* – by Z. Kopacz, W. Morgaś, J. Urbański (Naval University of Gdynia)
★ *Operational reliability of transport systems* – by J. Jaźwiński, Z. Smalko, J. Żurek (Air Force Institute of Technology, Warszawa)
★ *Prospects of application of natural gas to ship engines* by St. Żmudzki (Technical University of Szczecin)
★ *Contemporary systems for determining search areas at sea* – by Z. Burciu, J. Soliwoda, S. Ukleja (Gdynia Maritime University)

The remaining 119 papers were presented during 8 topical sessions on :

✦ *Modelling and simulation in navigation* (15 papers)
✦ *Operation of ship* (13 papers)
✦ *Navigational systems* (16 papers)
✦ *Safety at sea* (12 papers)
✦ *Ship combustion engines* (14 papers)
✦ *Ship systems* (17 papers)
✦ *State identification* (16 papers)
✦ *Operation of ship systems* (16 papers).

Several authors of the papers came from Russia and Ukraine. An attractive end of the Conference was the touristic voyage of its participants to Copenhagen, Denmark, onboard a ferryship.