The summary of doctoral thesis

THE USE OF NONCONVENTIONAL FUELS TO INTERNAL COMBUSTION ENGINES

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The use of fuels from vegetable oils at internal combustion engines has become a priority only in recent years, and this for cause related to the reduction of reserves of fuel of petroleum origin and especially the need to reduce environmental pollution.

Vegetable oils and animal fats represent an inexhaustible potential of energy, which have after processing, energy characteristics similar to those held by the diesel fuel (diesel). Thus it has proved that the final product of the transesterification namely the fatty acid of ester (bio-diesel) obtained from the processing of fat and vegetable oil has physical characteristics that are very close to the classic diesel fuel. Moreover, it should be named that these new fuels, methyl or ethyl esters of fatty acids can be used directly in diesel engines without any constructive changes resulting insignificant deposits during their combustion.

By doctoral thesis with the title **"The use of unconventional fuels to internal combustion engines"** we have proposed for study, analysis and accomplish the fallowing objectives:

- theoretical research regarding the main process of bio-diesel production;
- design and implementation of a pilot installation for bio-diesel production;
- researches regarding the proprieties of bio-diesel fuels;
- the experimental researches of the main influences on which bio-diesel have in a mono-cylindrical diesel engine;
- design and implementation of a stand for tests of the engine;
- experimental tests on a mono-cylindrical diesel engine with direct injection for determining the performance of various blends of bio-diesel and diesel at forced regime and in load;
- validating of the results theoretical and experimental.

The way for achieving these goals proposed is presented in nine chapters that are listed below.

In the first chapter **Introduction** it is made an overview of the necessity of using non-conventional fuels in the context of current situation in the world today.

The objectives proposed for solving this thesis, are presented throughout this chapter.

The second chapter **The actual study of the researches regarding the bio-diesel use** is intended to the presentation of the bio-diesel fuels, their spread across the European Union and the main raw materials used for their production. Chapter starts with a brief history on the use of bio-diesel in engines with compression ignition with mention to the first research on this domain and future prospects.

Romania's agricultural potential is high, it can annually produce over one million tones of oil from oil plants, and much of this production can be used to produce bio-diesel. According to statistics just 250000-300000 tones of oil are used for food, which means that a significant quantity of oil can be used for the production of bio-diesel of the first generation.

Production capacities of the 27 producers of bio-diesel in Romania may ensure the achievement of approximately 285000 tones of bio-diesel per year. The Kyoto Protocol at Convention of United on 11 December 1997 and ratified by Romania by law no. 3/2001 has as target the quantitative limitation and reduction of greenhouse emissions in required period of 2008-20012.

With the signing of the Kyoto agreement is given a great attention to the problems tied of the development of the component aiming the coherent developing of the production and researches in the domain of renewable resources in general and bio-energy in particular.

Romania assumed the obligations of European directives, but has not established a national initiative to stimulate development in this field. It is necessary to develop a strategy for medium and long-term to stimulate the production of bio-diesel.

In vegetal reign, from over 100 oil plants, currently in the world are highlighted about 40, grouped in 14 important botanical families of which we can produce bio-diesel. The factors that influence the demanding for bio-diesel are the price of petroleum and the retailers which have to promote this type of fuel.

In chapter three **Technologies for obtaining bio-diesel** is an overview of key technologies and methods for obtaining bio-diesel. From a technical point of view, bio-diesel is a methyl ester of a fatty acid. Bio-fuels diesel or alkyl esters may be obtained from oils and fats in three ways:

- catalytic transesterification of the oils with alcohol;
- catalytic transesterification direct acid of oils with methanol;
- the conversion of oils at fatty acids and then to alkyl esters with the help of acids catalysts.

In the situation in which the raw material contains high values of free fatty acids, is recommended the process of acid catalyses instead of basic.

The type and concentration of fatty acids of raw material determine directly some of the proprieties of bio-diesel. The conventional diesel fuel is composed of log chains of hydrocarbons without any ramification.

One of the important reasons that bio-diesel is a suitable substitute for petroleum diesel is that it consists of log chains without any ramification of fatty acids.

The choice of raw materials is probably the most important decision taken in the manufacturing process, because the cost of the raw material represents usually 60 - 80% of the total cost of production. Also, long-term availability of raw materials is an element that must be taken into consideration when making the selection of reactants.

The actual technology of production and processing of bio-diesel leads to an alternative fuel of good quality which satisfies the standards for bio-diesel and diesel fuel currently used today.

The main problem relating to bio-diesel in the last twenty years is the high costs of production caused by high prices of raw materials. At present, only residual fats of meat industry satisfy these requirements.

An alternative to make feasible economically the process of obtaining bio-diesel is to turn the other substances with value-added products from the process.

It is presented different methods of producing bio-diesel from de literature.

Installation of small capacity for bio-diesel is the name of the fourth chapter. It is presented two bio-diesel installation of medium capacity for bio-diesel production that is in use in present in Romania. We present a pilot installation of bio-diesel production designed and conceived in the Laboratory of Thermodynamics and Thermal Machines at Faculty of Mechanical Engineering of Craiova.

The principal goal of the experimental installation is the production of bio-diesel through the process of basic transesterification with methanol. It is described the equipment used for the realization of the installation, the methodology of testing and the obtained results.

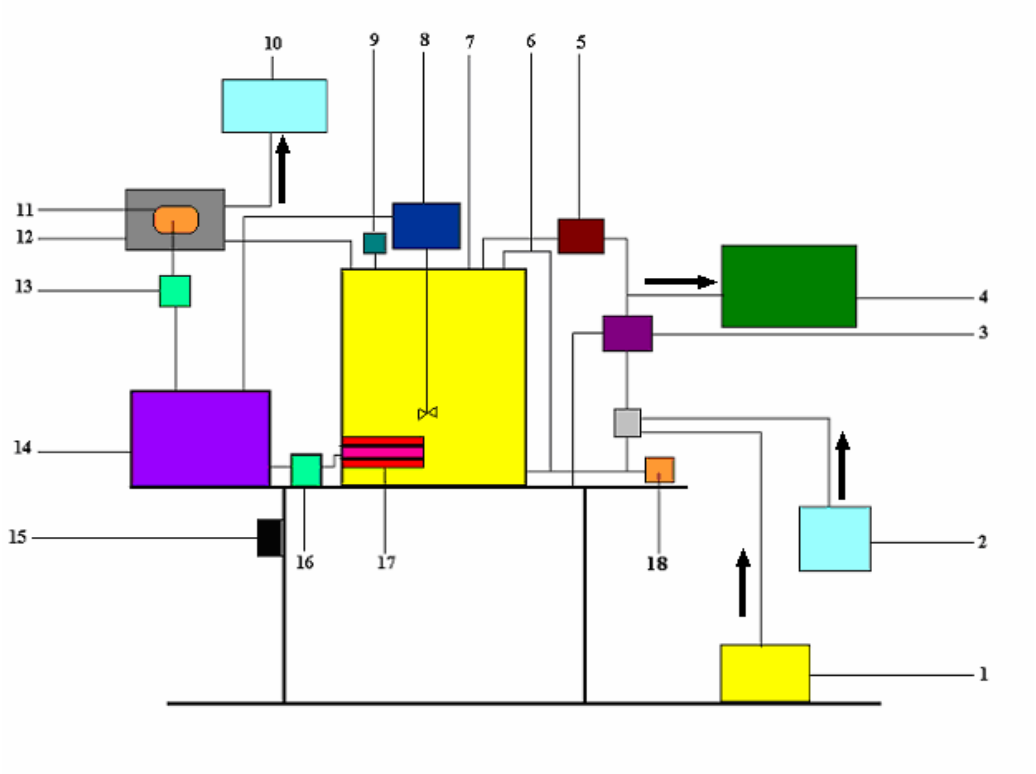

Fig.1 The scheme of principle of the pilot installation for bio-diesel production
1-oil thank; 2-metoxid thank; 3-pump; 4-biodiesel tank; 5-counter of hot water; 6-level pipe; 7-tank of 30 L; 8-electric stirrer; 9-pressure gauge; 10-methanol tank; 11-fan; 12-heat exchanger; 13-voltage range; 14-panel of control; 15-electric counter; 16-voltage range; 17-electric resistance of 2 kW; 18-thermometer;

Fig.2 Front view of experimental installation of bio-diesel production of Laboratory of Thermodynamics and Thermal Machines of Craiova.

In chapter five **Proprieties physic-chemical of bio-diesel fuels type** are analyzed the main proprieties of bio-diesel and petrodiesel. We present the standards for Euro Diesel and Super Euro Diesel. After that we passed in review different standards of bio-diesel for different European countries. We show the chemical composition of vegetable oils and bio-

diesel. It is been analyzed experimental the physical-chemical proprieties of different blends of bio-diesel and diesel (viscosity, density, flash point, cloud point, freeze point, elemental composition, thermal analysis), and then making a comparative analysis with different standards of bio-diesel.

The experimental analysis of the main physical-chemical parameters of bio-diesel fuel type shows that they can successfully replace classic petrodieselul.

Any problems that may arise from bio-diesel are the freezing temperatures and cloud point which are lower than diesel, which can create problems with engine power in areas with low temperatures. This can be resolved through the heating pipes of bio-diesel supply fuel.

Elemental analysis of fuels shows high level of oxygen content in bio-diesel composition which gives a better combustion in the engine and predisposition of this type of fuel for oxidation. It is recommended to use additives antioxidants on storage stability.

Although in the transesterification process is greatly reduced the viscosity of bio-fuels they have a viscosity of two, three times higher compared to diesel fuel.

Bio-fuels have a flash point over 100 ° C compared to diesel which makes possible the storage and the use of them safely.

By thermal analysis of different mixtures of Diesel Euro L Diesel and Bio-diesel from rapeseed on curves TG, DTG, DTA it is observed a increases of temperature of vaporization with to increase in the bio-diesel content. Is an increase of carbon deposits which can affect in case of long use the performance of the engine.

In chapter six **Techniques and Methods of theoretical investigation of mixture formation and combustion in m.a.c.** for bio-diesel fuel type we present the phenomena's and process which occur at the burning of the diesel fuels. Chapter starts with the presentation of theoretical considerations on auto ignition and combustion on engine with ignition through compression with direct injection.

It is presented a comparative study regarding the models for calculus for modeling of combustion process in diesel engine. Thus, it is done a presentation of the thermodynamic models uni-areas and multi-areas as well as the phenomenological zero-dimensional which have the highest spread and applicability.

After that it is passed in review the methods of theoretical and experimental investigation of mixture formation and combustion. It is presented the researches on the experimental investigation of auto ignition, then are highlighted the investigation methods of the combustion of performed blends and of moderate burning. Are inventoried the main techniques of theoretical investigation.

It is presented a theoretical calculation of complete and incomplete combustion of three types of bio-diesel compared to diesel. In case of complete burning of bio-diesel type fuel we have noticed a reduction of oxygen and the minimum air necessary to combustion due to the presence of oxygen in their composition. The quantities of combustion products for complete and incomplete combustion record a decrease for the three types of bio-diesel compared to diesel which suggests a reduction in emissions of burning gases.

In chapter seven **Experimental and theoretical research on the influence of the use of biodiesel fuel on emissions of the mono-cylindrical engines with direct injection** it is presented the experimental results from tests on two mono-cylindrical engines of Laboratory of Thermodynamics and Thermal Machines of Craiova.

The chapter begins with the presentation of the factors which influence the genesis of polluting substances at engines with ignition through compression. Then it is presented the general effects of polluting substances with a series of reactions that occur in presence of the combustion gases resulting from combustion of classic diesel.

It is presented the equipment (Fig. 3) used for experimental tests on the engine RY 50 and then are tested various blends of bio-diesel from rapeseed and sunflower and palm oil with Euro L Diesel.

The tests consisted in lifting characteristics of engine function of speed of crankshaft without load at forced regime with registration of following parameters (carbon monoxide, carbon dioxide, hydrocarbons, and engine oil temperature) for ten speed regimes.

There is a reduction of pollutant emissions from all bio-diesel blends compared with classic diesel.

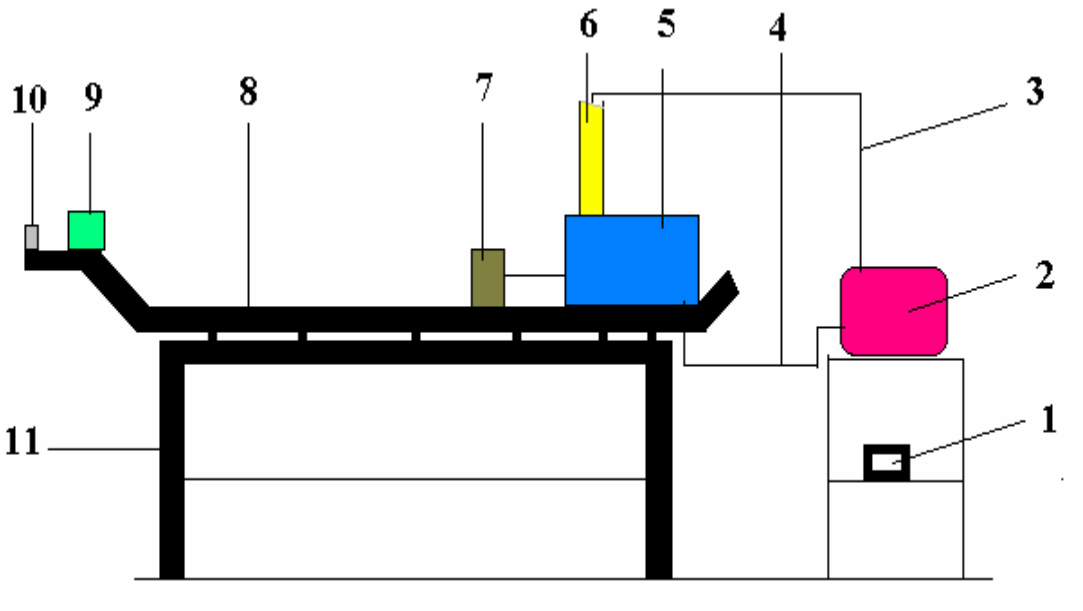

Fig.3 The schemes of principle of the RY 50 stand

1-thermometer; 2- analyzer of gases Stargas; 3- sensor for analysis of CO, CO_2, HC, O_2; 4-oil temperature sensor; 5-diesel engine RY 50; 6-pipe of evacuation chamber; 7- tachometer; 8-metalic support for the engine; 9-mechanical device for the regulations of turation; 10- engine stop; 11- table;

It is presented the equipment (Fig.12) used for the second mono-cylindrical diesel engine KM186FA (the engine is part of electric generator Kipor 6500E).

The tests consisted in lifting characteristics of engine function of load with registration of following parameters (carbon monoxide, carbon dioxide, hydrocarbons, and engine oil temperature) for five speed regimes for different blends of bio-diesel of rapeseed and diesel.

Fallowing the analyses of the results obtained we notice a reduction of gases emission for the majority of blends used.

The results of researches on the two mono-cylindrical engines through the reduction of gases emission have confirmed the results obtained by on theoretical way of the study of theoretical combustion for bio-diesel fuel types.

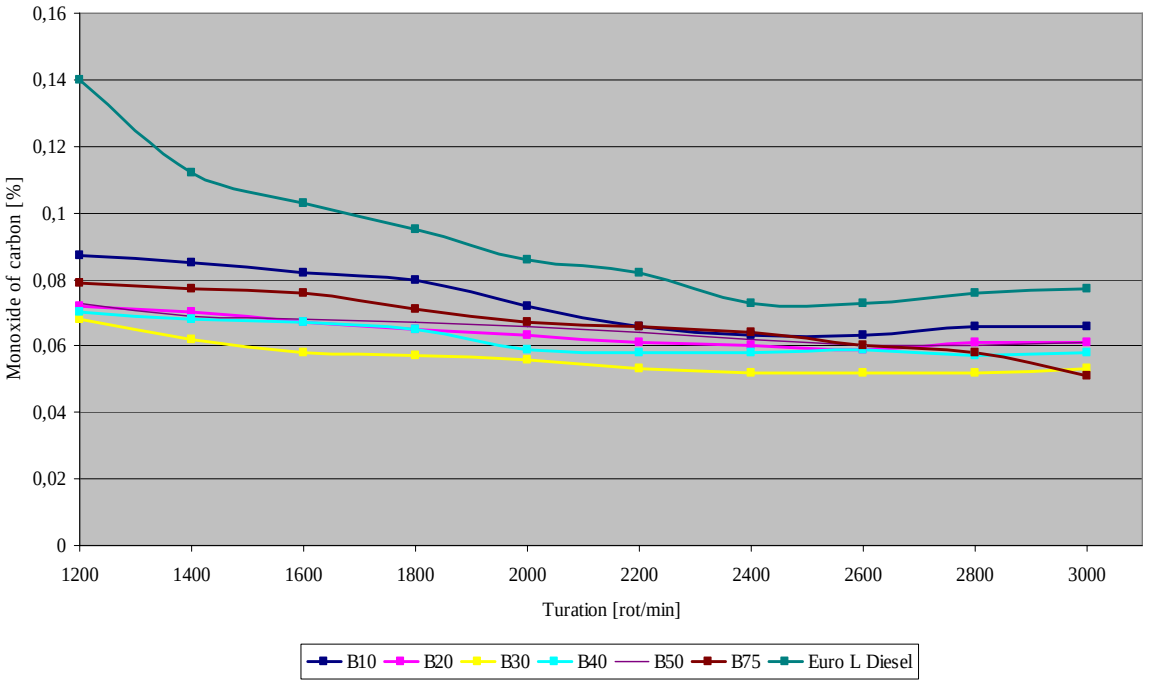

Fig.4 The variation of monoxide of carbon function of turation for different blends of Biodiesel of rapeseed ad Euro L Diesel

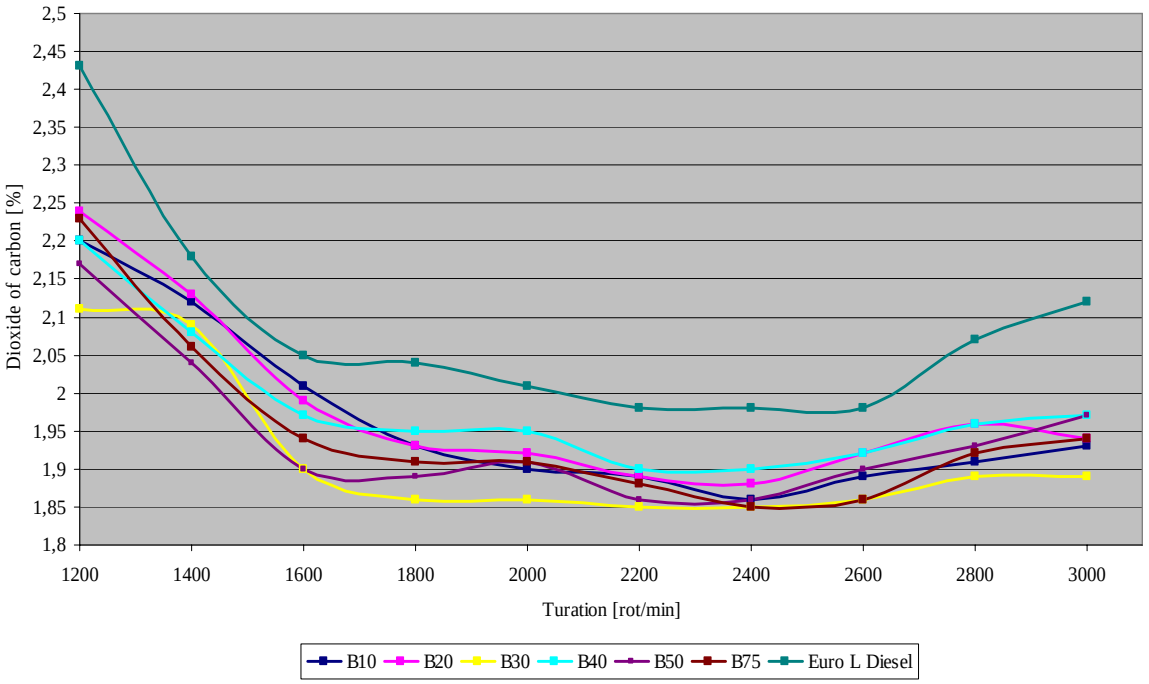

Fig.5 The variation of dioxide of carbon function of turation for different blends of Biodiesel of rapeseed ad Euro L Diesel

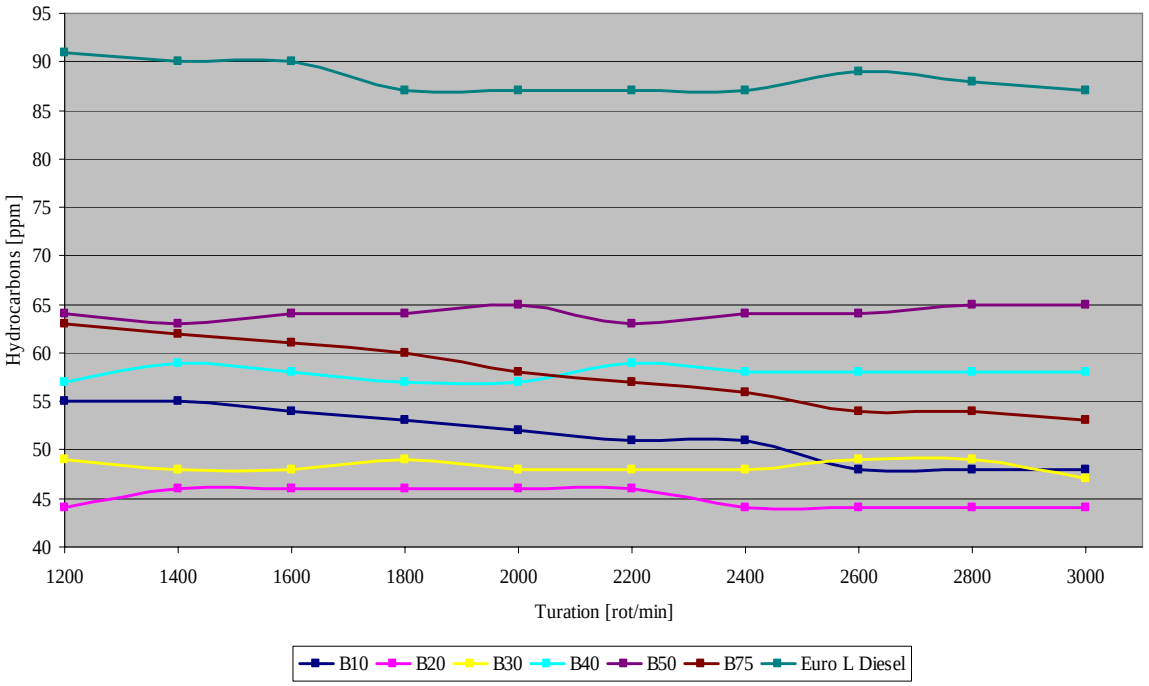

Fig.6 The variation of hydrocarbons function of turation for different blends of Biodiesel of rapeseed ad Euro L Diesel

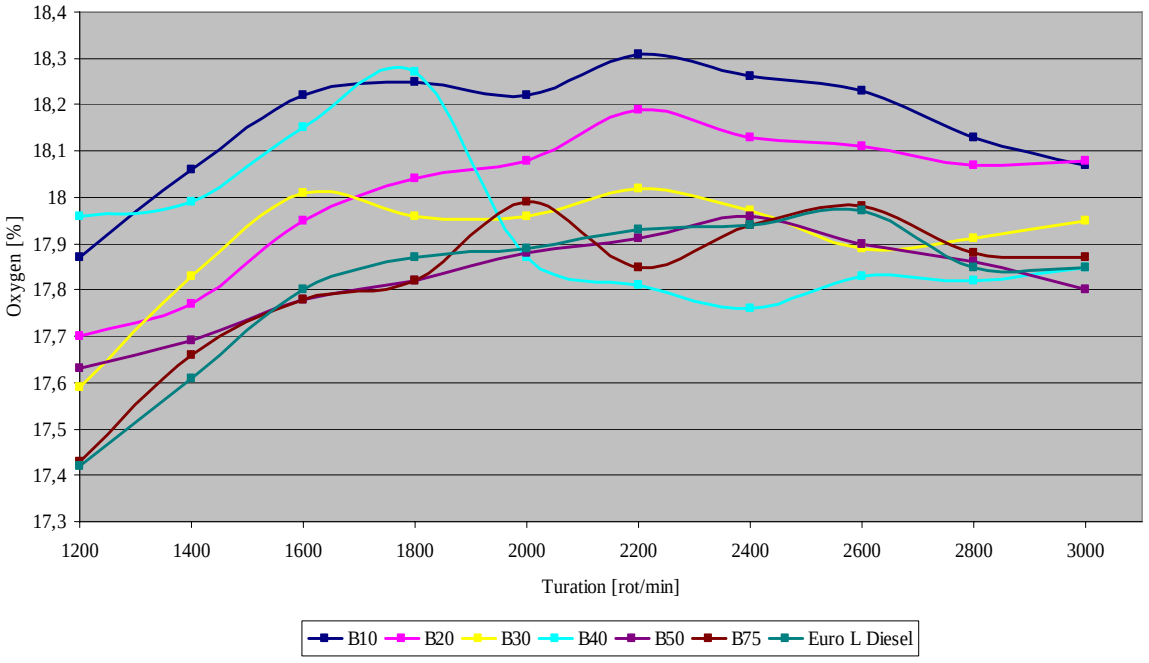

Fig.7 The variation of oxygen function of turation for different blends of Biodiesel of rapeseed ad Euro L Diesel

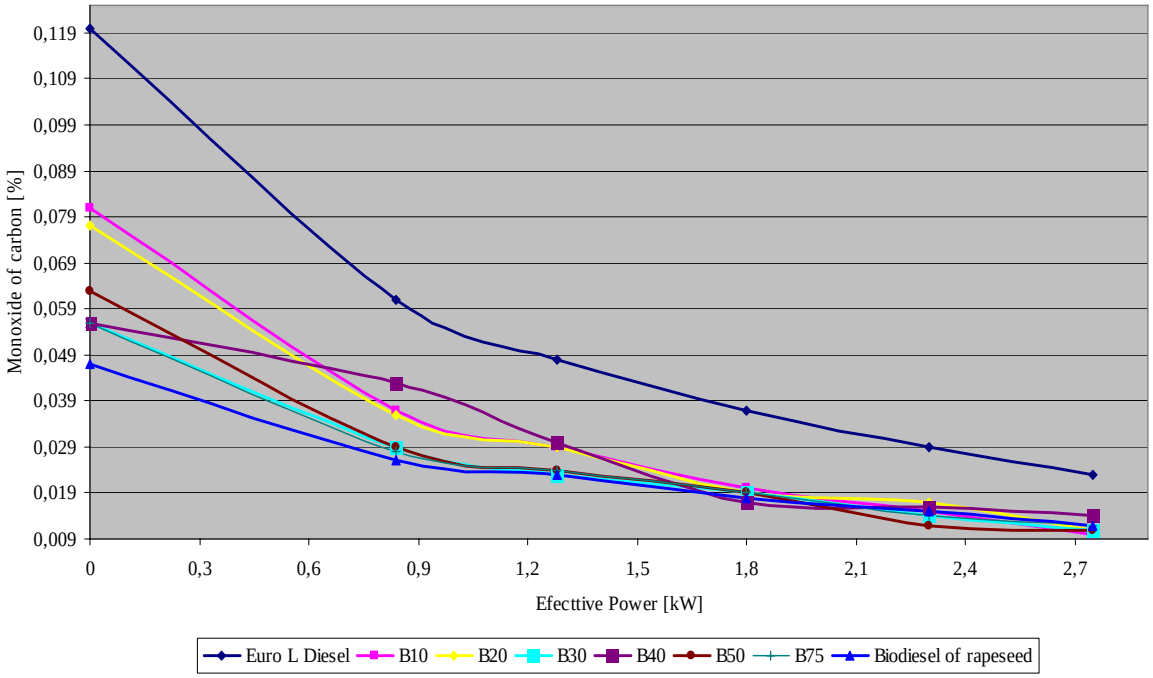

Fig.8 The variation of monoxide of carbon function of load for different blends of Biodiesel of rapeseed and Euro L Diesel

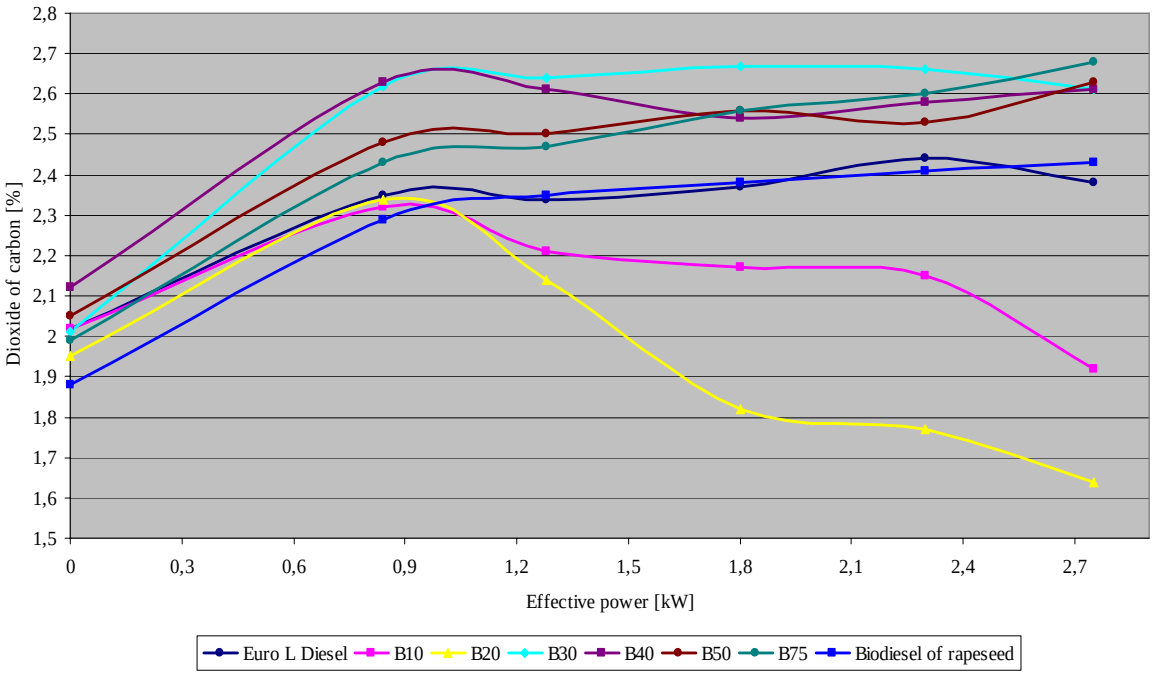

Fig.9 The variation of dioxide of carbon function of load for different blends of Biodiesel of rapeseed and Euro L Diesel

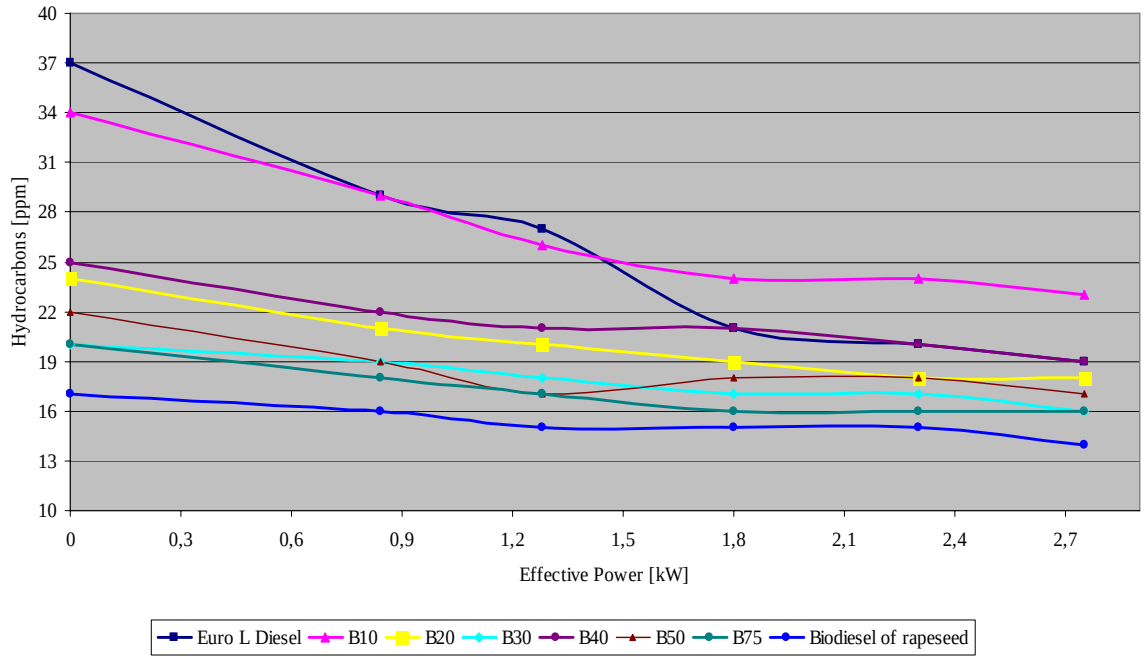

Fig.10 The variation of hydrocarbons function of load for different blends of Biodiesel of rapeseed and Euro L Diesel

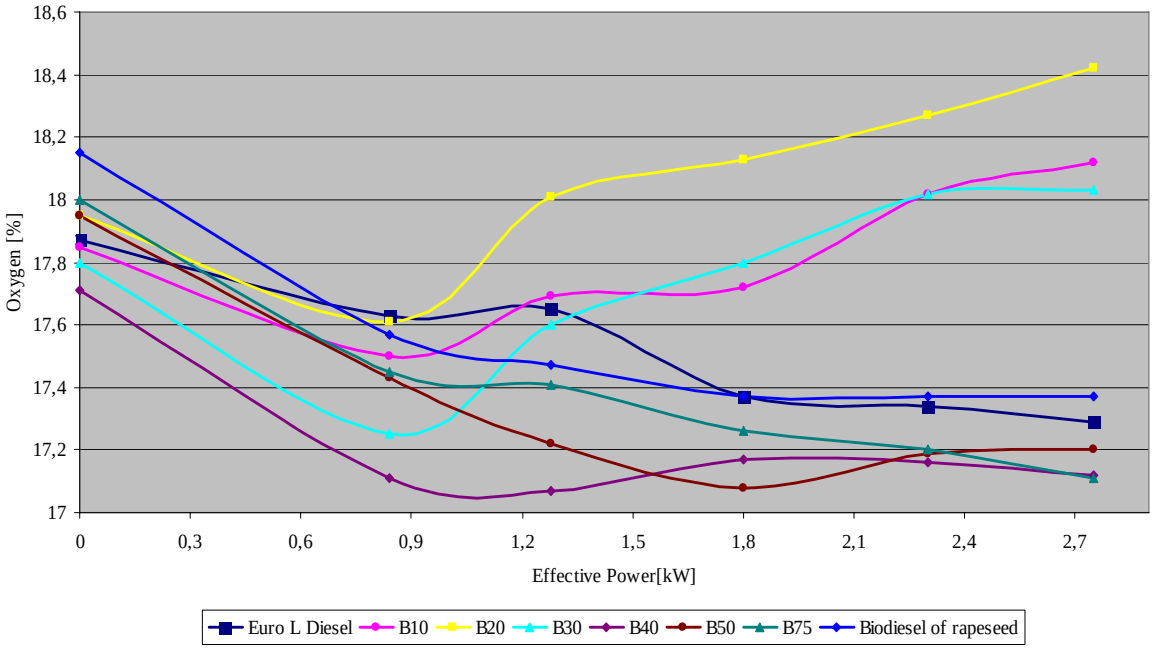

Fig.11 The variation of oxygen function of load for different blends of Biodiesel of rapeseed and Euro L Diesel

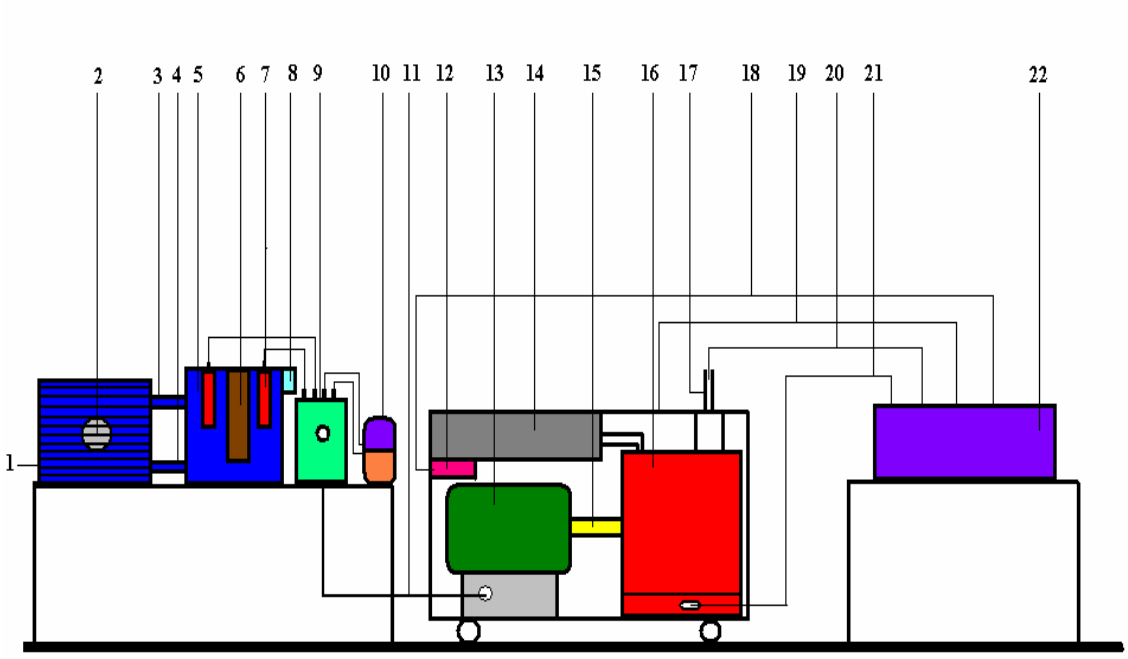

Fig.12 The schemes of principle for the engine KM186FA

1-heat exchanger; 2-fan; 3-pipe; 4-pipe; 5-oil tank; 6-oil pump; 7- electrical resistances for heating (2kW); 8-panel of command; 9-adjustable auto-transformer; 10-voltmeter and ammeter; 11-cable of alimentation; 12-batery; 13-electrical generator; 14-fuel tank; 15-transmission; 16-diesel engine; 17- pipe of evacuation of gases of combustion chamber; 18-cable of measurement of r.p.m; 19-cableof mass; 20- well of burning gases; 21- oil temperature sensor; 22- system of measurement of pollutant gases STARGAS 898;

In chapter eight **The experimental and theoretical research regarding the noise emitted by engine when is fueled with bio-diesel fuel type** it is presented the experimental researches conducted on an engine with mono-cylindrical with measurement of noise level for different blends of bio-diesel from rapeseed and Euro L Diesel. Although the engine structure is solicited by many forces, we will be presented the correlating of noise emitted by a single exciter force, determined from the combustion process, considering that its effects are dominant over those of other forces. It is presented the equipment used for measurements.

The tests consisted in measuring the noise level at distance of 0.5 - 1 m from the engine into four symmetrical points (A, B, C, and D) around the engine function of speed of the crankshaft of the engine.

Based on the analysis of functional parameters of the engine fueled with Diesel fuel, it can be affirmed that the alimentation with bio-fuels can provide a noise reduction. In general, combustion is more efficient in the case of use of these fuels compared to diesel, because of the oxygen present at molecule level of ester and higher cetane number of bio-diesel. The largest reduction in noise generated by the engine compared to diesel Euro L Diesel is -2.85% recorded at speed of 1600 rot. / min. for B75 at distance of 0.5 m from the engine in point C.

In chapter nine **Final conclusions and personal contributions** are summarized the main contributions of the author, the final conclusions of the thesis and future research for use of bio-diesel in engines with compression ignition.