ABSTRACT OF THE PhD THESIS

„Researches regarding the use of rape oil fuels in comparison with Diesel at the compression ignition engine for the diminution of pollution”

Eng. Nicolae N. CORDOȘ

1.1. The purpose and objectives of the PhD thesis

In the present conditions regarding the need for the development of renewable energy sources for the future sustainable development of the human society, the determination of the conditions for the use of fuel based on rape oil at the compression ignition engines represents the purpose of this PhD thesis, thus trying to establish the technical conditions that those engines need to have and the pollutants produced by them when using the above mentioned fuels.

The theoretical as well as experimental approach has been achieved on an interdisciplinary basis, by correlating the knowledge and researches in fields like: mathematics, chemistry, physics and mechanical engineering.

The main objective of the thesis is directly linked to the ways and usage limits of biodiesel for the compression ignition engine. The premises to successfully finish the objectives of the thesis are represented by the development and implementation of a research methodology structured as follows:

- the mathematical modeling of the fuel jet;
- the experimental validation of the mathematical model;
- testing the physical-chemical parameters of the used biodiesel;
- experimenting in functioning conditions of the tested biodiesel;
- the analyses as methodology and the interpretation of the obtained data
In order to achieve the main objective of the PhD thesis, within each chapter (in the research of the possibilities to use rape oil bio-fuels) there have been specific quantifiable objectives connected to the approached research methodology.

The estimated impact of the thesis is a complex one, because it has a multi and inter-disciplinary character with benefits on the social, environmental, economic and technical environment.

1.2. The contents of the thesis

The thesis is structured in 6 chapters. Starting from notions related to the need of the proposed theme and the pursuance of the established objectives, the thesis continues in a natural succession, thus:

- Bibliographical researches regarding the present stage in the development of the field (Chapter 2):
  - the development of fuels for vehicles and the tendencies to use fuels based on rape oil for the compression ignition engines;
  - the physical-chemical characteristics of the fuels based on rape oil in comparison with Diesel;
  - present studies regarding the use of fuels based on rape oil at the compression ignition engines with respect to the changes of the engine for pure rape oil fuels and vegetal oil;
  - cases of refuelling with biodiesel mixture of compression ignition engines.

- The theoretical and experimental modeling of refuelling with rape oil on the engine D-2402 (Chapter 3):
  - the theory of fuel jet and its vaporization;
  - the modelling of the flow into the outlet of the injector;
  - the multidimensional modelling of the fuel jet;
  - the dynamics of the fuel’s pulverization, the dynamics of the jet;
  - some theoretical and experimental results regarding the dynamics of the fuel’s pulverization.
The experimental results concerning the self-ignition and burning of rape oil in comparison with diesel have been discussed in Chapter 4:
- the physical-chemical properties of the experimented fuels;
- the self-ignition qualities of the mixture of rape oil fuel and Diesel;
- the self-ignition and burning qualities of the doped rape oil and Diesel;

- Chapter 5 presents the experimental trials that have been achieved on the engine D-2402:
  - the stand for trying the compression ignition engines refueled with fuels based on rape oil;
  - the methodology of starting and trying the compression ignition engine refueled with fuel based on rape oil;
  - the main parameters of the D-2402 engine refueled alternatively with rape oil fuels and Diesel;
  - the experimental results.

- Chapter 6 presents the experimental researches regarding the diminution of pollution of rape oil fuels. This chapter has been structured as follows:
  - the procedure to determine the composition and opacity of the waste gases;
  - the used apparatus;
  - the experimental results.

The studies, researches and experimental attempts that have been undertaken within a development of an algorithmic research basis for the compression ignition engines have allowed the possibility to state some conclusions regarding the researched theme.

These conclusions, based on the results that have previously been presented are:

- The real need to find renewable energy sources for the compression ignition engines, due to causes related to the diminution of the oil resources and especially due to the diminution of environmental pollution (an original idea of this thesis), can be considered as a continuous concern
for the researchers of the field, within the majority of the world’s countries interested in this;

- The use of bio-fuels based on rape oil for compression ignition engines is not possible on long term without any problems, due to its properties that differ a lot in comparison to those of Diesel (viscosity, behavior at boiling and so on). Thus, the fuel needs to be adjusted to CIE (compression ignition engine) by converting vegetal oils to methyl esters of fat acids (Rape-methyl-ester) or the adjustment of the engine to this oil. For both cases there are some elaborated practical procedures;

- The use of mono-esters obtained by trans-etherification of vegetal oils with inferior alcohol as fuel for CIE does not involve constructive changes of the engine;

- The sediments are bigger for vegetal oils, which creates some disadvantages for refueling, in time. Pollution is more reduced for vegetal oils in comparison to Diesel, which represents the main advantage;

- Viscosity of the rape oil based fuel is, especially at low temperatures, many times higher than the ne of Diesel. The inflammability point is, at more than 220°C, a lot higher than the one for Diesel, having positive effects on warehousing and transportation, but it requires technical adjustments of the engine;

- The mono-esters obtained by trans-etherification of rape oil can be used in their pure state for refueling the compression ignition engines or they can be mixed in different proportions with the classical Diesel in order to create fuel mixtures that can be used as fuel for these engines. These mixtures do not raise any problems regarding separation and generally present physical-chemical properties similar to those of Diesel;

- The modeling of the temporary development of the fuel jet, starting from the pulverization point show that the further parameters which define the
injection process of the fuel in the combustion chamber depend on this outlet, the injection pressure, the fuel’s properties and the counter-pressure in the ignition chamber;

- The modeling of pulverization, its homogeneity, the jet’s penetration and the dispersion angle are similar to the ones for Diesel and rape oil. The closed values of these characteristics of rape oil compared to the witness fuel – Diesel, can be noticed especially at increased temperatures and injection pressures for rape oil;

- The dynamics of the fuel’s jet pulverization establishes the injection speed, angle and penetration, the initial diameter of the fuel drop – important parameters in defining the injection process;

- The average diameters of the drops that represent the jet are influenced in a much stronger way by the fuel’s viscosity and not by the injection’s pressure. This phenomenon has to be correlated to the equilibrium of the inner and outer forces that act on the fuel drop;

- Higher the density of the fuel is, the more the homogeneity of pulverization in the ignition chamber suffers, resulting in an incomplete ignition. The density decreases with the increase of the fuel’s temperature.

- Viscosity influences the refuel of the engine and the fuel’s pulverization in the ignition chamber. The increase of viscosity disfavors the pulverization and ignition of the fuel in the engine. A too viscous fuel will worsen the formation of the fuel mixture, because the drops, being big and penetrating, will reach the opposite wall of the injector. The contact surface being colder, will determine the break of the ignition chain reactions;

- According to the experimental results, it has been noticed that the value of the cetane number for the used fuels within the experiments decreases
according to the concentration of rape oil, and the beginning of the main ignition is connected to the cetane number of the experimented fuels;

- The delaying period at self-ignition is strongly influenced by the physical-chemical properties of the fuel. In order to have a good ignition of the fuel in the ignition chamber, it has to spontaneously burn and have a minimum self-ignition delay;

- A minimum diminution of the ignition time gives the engine maximum powers and efficiency;

- The experimental attempts have underlined the benefic influence of the content of a certain percentage of additives on the self-ignition and ignition characteristics for rape oil. Thus, doped ape oil with the additive ethyl-hexyl-nitrate behaves closed to Diesel. This additive increases the value of the cetane number with 16.5% than non-doped rape oil. The additive ethyl-hexyl-nitrate that has been use in 2% is the closest one to the values of Diesel;

- After the experiments and results regarding the main characteristics of the compression ignition engine that function on fuels based on rape oil it can be stated that these fuels offer the engine almost the same performances as Diesel, which makes these fuels competitive;

- It can be noticed that the use of bio-fuels based on rape oil in refueling the compression ignition engines has lead to values, which are smaller than the ones measured for Diesel with respect to the majority of the pollutants. Thus, it can be stated that there are real advantages in comparison to Diesel. The tests have showed that rape oil fuel is viable from the point of view of polluting the environment and its usage as fuel.

Among the author’s contributions for achieving the established objectives of this PhD thesis, the following can be mentioned:

- A bibliographical study on the literature and researches in the field;
The theoretical and experimental modeling of refueling with rape oil for the engine D-2404, establishing the main characteristics of the rape oil jet in comparison to Diesel;

Determining and studying the main physical-chemical properties of the experimented fuels. These experiments have been achieved within the institute "ASG Analytik Service-Gesellschaft" in Augsburg (Germany), an institute that pursues the determination, evaluation and classification of oils and fuels that are used in the auto industry.

The determination of the self-ignition and burning characteristics of the mixture of rape oil based fuels with Diesel. Researches have been done on the rape oil based fuels and their mixtures with Diesel, as well as on doped rape oil with different additives. Within these experiments the following have been determined: the average delay at self-ignition, the beginning of the main ignition, the time of ignition, the cetane number, the maximum position of the speed of the throwaway heat and the maximum level of the speed throwaway heat

The elaboration of the functional scheme of the stand for trying the compression ignition engine fueled with rape oil based fuels;

Experimental attempts for establishing the influence of rape oil based fuels on the functional performances of CIE;

Experiments for establishing the influence of rape oil based fuels on pollution, in comparison to Diesel;

A comparative evaluation of the functional parameters of the engine fueled with rape oil based fuels;

A comparative evaluation of the pollutant emissions produced by the engine fueled with rape oil based fuel;
The evaluation of the performances of the engine D-2402, by setting its complex characteristics for the use of fuel rape-methyl-ester.

The paper is only a small step forward in the study of compression ignition engines that use biodiesel based on rape oil and it opens new direction for development by offering a series of experimental data and theoretical instruments, needed for the further improvement. The investigation in this field have to go on, by pursuing:

- The activation of the production of oleaginous plants (for biodiesel), which represents an alternative that is profitable for farmers, being complementary to the existing cultures and representing an income source for agriculture;

- Establishing new technologies for processing raw oils in order to adjust their physical-chemical properties to those of Diesel;

- Developing a common European standard for biodiesel;

- A constant participation to the international actions that are meant to evaluate and contribute to the awareness of the impact of transportation of the environment;

- The achievement of new experiments in the current exploitation of tractors and vehicles that have CIE, in order to determine the effects of the use of biodiesel, so that pollution will be diminished.