

Alternative Fuelling of Diesel Engines With Diesel Fuel and Raw Vegetal Oils: Achievements, Problems and Perspectives

Mircea Adrian NICOLESCU

National Institute of Research – Development for Machines and Installations Designed
to Agriculture and Food Industry – INMA, Bucharest, Romania
m_a_nicolescu@yahoo.com

Abstract: The paper presents the general aspects of bio-fuels usage, with its advantages, disadvantages and actual limitations. There is exposed a synthesis of the attempts which consists of using the raw vegetal oils at powering the diesel engines, engines initially conceived for diesel fuel powering, both in the diesel fuel – vegetal oil mixtures alternative and in the using of vegetal oils as such alternative. In this context, there is presented a systematic analysis of the technical problems raised by this practices and are emitted some hypotheses looking their genesis. At the end, there are exposed some possible solutions for the identified problems, resulted from the author's experience.

Key words: Diesel engine, biofuels, raw vegetal oils.

GENERAL CONSIDERATIONS

At the current level of human society development, the fossil fuel-coal, bituminous schists, oil, natural gas - practically represent the most important source of power. Any attempt of a hierarchy in the importance of each of the above mentioned fuel categories strikes a multitude of criteria which care be invoked and which finally should be classified in a hierarchy by attributing them an influence importance. In this way, among others, the following can be invoked as hierarchy criteria:

- the importance of each type of fuel in the total inheritance of "fossil power" of mankind;
- the maturity levels and the dynamics of the specific exploitation technologies (extraction, processing, distribution, use);
- the assignment levels of the environment when applying the specific technologies of exploitation;
- the degrees in which some of the resources are claimed in a competition way, as indispensable raw materials in non-power engineering industries;
- the uniformity and security of commercial conditions of access to the resources;
- existence of some important activity domains and totally dependent on a certain type of resources.

In respect of the results of a hierarchy according to some criteria of the above-mentioned

type, one should remark that, within the assembly of the current organization of the human society, the oil-rooted fuels have, beyond their importance of about 50% from the total of produced power, a fully special position due to the following aspects:

- practically they constitute the only source of feeding the heat engines, so that they fully cover the power requirement for the domain of transport and the necessities of producing power in non-integrated systems;
- the primary oil resources are mostly grouped in geographical basins associated from the population and political point of view to some cultures and some disjoint political interests (the middle East area, the Caucasus area, the North Sea area, the South American area).

The conjugation of these two aspects with some political junctures more or less extended has made that in the latest seven decades the world economy confront with some episodes of oil resources crisis. The first important crisis of this type took place during the second World War. When the European area controlled by Germany knew a major oil crisis due to the conjugated effect of the big military consumptions and to the impossibility of getting the control on some major oil areas. The next crisis episode occurred in the

middle of the eighth decade of the last century was generated by the political answer of the Arabian countries when testing the re-modelling of force ratio in the area and practically effected the whole mankind. A new oil-resource crisis episode, also felt by all mankind, started in 1990, alongside with the invasion of Kuwait by Iraq and it is going on with some relaxation periods, until nowadays.

ALTERNATIVE SOLUTIONS FOR FEEDING THE INTERNAL COMBUSTION ENGINES

The effects of the oil crisis episodes during the post-war period have always consisted in a re-setting of oil prices to higher levels, with unfavourable consequences on the world economic equilibriums and the industrial increase rates of all states. On the background of these consequences, in the family of industrialized countries the concept of **power safety** occurred, under the standard of which there were made and started some arrangements regarding some planned rhythms of crude oil extraction and some predictable evolutions of its market prices. At the same time, having a statute of a party in the power security, the concept of **power independence** has started being examined and has developed. Under a general power aspect this concept has generated, at the level of each state or some state groups, various strategies for developing and promoting some intensive technologies for getting power - as the nuclear fission reactors - or some durable technologies for obtaining power - as the hydro - power facilities. Under a peculiar aspect, but very important at the same time, for the fuels for heat engines, the concept of power independence has activated some preoccupations for obtaining **alternative fuels**.

The alternative fuels for feeding the internal combustion engines should, obviously, not contain any oil contribution and should be able, in a perspective connected to the real term of exhausting the oil resources, to be produced in sufficient quantities for covering all the reasonable oil requirements. Under the historical aspect there is the precedent of a technology of obtaining the synthetic gasolines by the chemical processing of lignite (the German concern IG Farben Industrie, 1943). Beyond the aspect of profitability of this performance, being

negatively influenced by the costs of extraction and primary processing of lignite, currently it is obvious that the efforts of replacing the oil fuels should not be based on some other fossil resources - inherently exhaustible - but on renewable resources.

In these conditions, if we do not take into account the possibility of obtaining hydrogen by decomposing the water by using the solar power - a version which can be neglected because the use of hydrogen when feeding the internal combustion engines raises some problems difficult to be solved, the only renewable resources which can be used in order to obtain alternative fuels for engines are those biologically - rooted. As a result, the viable solution of alternative fuels obtained from renewable sources, for feeding the internal combustion engines, is represented by **biofuels**. This assertion is supported by some achievements which now are already commercially exploited and are in full stage of technological development.

The biofuels for feeding the internal combustion engines represent a solution of lasting development in power engineering, because, besides the aspect of obtaining the power from renewable sources, the use of biofuels also leads to some important reducing of the polluting emissions from the engine exhaust gases. Moreover, in the case of biofuels use, the main burning product the carbon dioxide - is the result of the combination of the carbon in the natural circuit and not of the fossil carbon, as in the case of classical fuels, which means that the biofuel burning does not contribute to the final increasing of the atmospheric charge with carbon dioxide, responsible for the hot house effect. That is why the promoting of biofuel use for feeding the internal combustion engines has become the subject of some specific regulations within the power and environment policies.

PRACTICAL IMMEDIATE VERSIONS FOR USING BIOFUELS

The economic and technical conditions which create the promoting medium for a biofuel current use, as they have been presented up to now, place the **biodiesel** - type fuels on the first range between the alternative versions of feeding with biofuels of the internal combustion engines and leave open the option for any of the following positions. Here we

advance the hypothesis that another version, an interesting one and able to a relatively fast dissemination, for feeding the engines, is that one of using **vegetable oils**.

The generic name of "Bio-Diesel" is given to some fuels designed to feed the compression ignition engines (Diesel) which have as major components some methylic esters of fatty acids obtained by the methanolysis of (simple) triglycerides from vegetable oils. Generally the Diesel fuel meets the requirements of combustion within engines in a resembling way as with the Diesel fuel.

The use of vegetable oils for feeding the compression ignition engines is not a novelty. Thus, looking at things from a historical perspective, we can mention the fact that at the Universal Exhibition in 1900 in Paris, Rudolf Diesel himself made some demonstrations with an engine invented by himself being operated by pecan oil. Moreover, it seemed that he inferred the matters and preoccupations connected today to the domain of alternative fuels for engines, the same Rudolf Diesel asserted, in 1991, that "The engine can be run by vegetable oil and this could be a considerable help for the agriculture of the respective countries" and in 1912 he declared that "The use of vegetable oils for feeding the engines can have no importance today, but they can become, by time passing, as important as oil and coal is now". Also, it is known the rather spread usage of the rape oil for filling of some Diesel engines in the first decades of the last century.

More recently, the preoccupation for the alternative of using raw vegetal oils for filling the autovehicles engines has reappeared after the oil crisis from the beginning of the 8 decade of last century. Thereby, in that period, big autovehicles constructing companies (General Motors in SUA, Audi and Daimler – Benz in Europe) have done tests with autovehicles of which engines were endowed with injection equipments especially conceived for using oils. The results of these tests were satisfying, the only appeared problems being linked by the apparition of some gum deposits in the injection installations and inside the cylinders.

Obtaining the vegetable oils able to be used as fuels for engines is much simpler than obtaining biodiesel. Definitely, for obtaining vegetable oils there

must be covered only the stages of extracting the oil out of the oleaginous seeds and its purifying by degumming, settling and filtering processes. Further on, the profitability of these processes is not conditioned by the production extension and by maintaining its continuous flow. As a result, the producing of vegetable oils designed to be used as engine fuels can be organized, without considerably affecting the profitability, in local sectors, placed nearby the users and dimensioned according to their needs. It is doubtless that these aspects, alongside with the general advantages of using biofuels, make the use of vegetable oils as fuels an interesting target, especially for the agricultural exploitations, where this practice would mean ensuring the fuels by own efforts and obtaining a power independence in this regard.

At the actual time, the challenge is not to demonstrate the possibility of using the raw vegetal oils for fuelling the engines – already historical attested – but to find some filling technologies which to enable the usage of raw vegetal oils for the already servicing engines and fitted with injection equipments conceived for fueling with diesel fuel. The obstacles which stand in front of such practices are constituted by the big viscosity of the raw vegetal oils, by the existence inside them of some components with high tendency of depositing (the so-called "gums") and by the cetane number, much more lowered than the diesel fuel one.

The historical validation of the possibility of feeding the compression ignition engines with vegetable oils and the relative easiness of their obtaining seem to point to this solution as being the most comfortable way of substituting the oil fuels.

In fact the adopting of this solution should be cautiously performed because some properties of vegetable oils substantially differ from those of the Diesel fuel and can influence in undesirable ways some aspects in engine running. The tests performed in this regard have emphasized the following difficulties for which the profile research should find solutions:

- the vegetable oils have shown an aggressiveness to the rubber gaskets within the engine feeding systems;

- the viscosities of vegetable oils to environment temperatures are much higher than the Diesel fuel viscosity and this aspect negatively influences the dynamics of the injection process;
- the values of oils surface tensions are much higher than the suitable value of Diesel fuel which results in reducing the quality of the spraying process accompanying the fuel injection;
- the cetane number of vegetable oils is substantially lower than that of the Diesel fuel, which makes the engine starting difficult and, after starting, it negatively influences the self-ignition processes as regards duration, leading to undesirable modifications of the combustion dynamics.

The first one among these difficulties can be easily solved by replacing the formerly referred gaskets with some ones manufactured from equally compatible materials to biodiesel and Diesel fuel. As regards the other difficulties let us notice that their manifestations aim the perturbation of self-ignition and combustion processes which are essentially liable for the operating output of engines. Consequently, these difficulties will have to be dealt with in an integrated manner within some researches which should indicate several solutions for maintaining the quality of self-ignition and combustion processes to an acceptable level. Such solutions may comprise some measures for directly influencing the properties which represent difficulties. For instance, the oil pre-heating can be a method for reducing its viscosity and surface tension. Also, in order to promote a high-quality atomizing there can be practised some increases of the injection pressure up to the limits which also allow the alternative operation with Diesel fuel. As regards the compensation of lengthening the self-ignition duration, there must be searched the measure in which this can be done on the way of an adequate modification of the advance characteristic when injecting.

In present there are signaled some restrained practices of alternative usage of vegetal oils at fueling the agricultural tractors (United States, Germany, France), using a technology in which the degummed oils are heated by the cooling agent from the engine. Such practices are somehow controversial, because the heating until approximate 100°C cannot reduce

enough the oils viscosity and the increments of loads in the injection equipments, due to the big viscosity, often provokes their damage.

In completion of the reminded practices, it has to be mentioned the conduct of partial replacement of the diesel fuel by usage of mixtures diesel fuel – raw vegetal oil. The large scale advertisement of this conduct and the relative silence of the specialty scientific mediums towards this one have inspired the performing of some researches of which results are described, succinct, in continuation. These researches, performed with accuracy and professionalism, have comprised comparative tests regarding the performances determination of a test engine at filling with diesel fuel and with mixtures.

THE "ENGINE PERFORMANCES" EVALUATION OF DIESEL FUEL - VEGETAL OIL MIXTURES

The test engine comportment evaluation at fuelling with mixtures was done by comparing the engine performances at successive fueling with diesel fuel and mixtures containing 10 %. 20 % and 30 % vegetal oil. The test engine was of D115 type and has equipped an agricultural tractor of 445 type. The tests have sighted out the raising of the rotative speed characteristic at engine's total load, in the conditions in which the load control of this one was done through the medium of the tractor's power shaft. For increasing the test obtained data representance, for each fueling alternative were raised more characteristics, their number being dictated, in each separate case, by the results dispersion stabilization. This way, each engine comportment could be appreciated both by the medium values of the obtained measures and by the engine's fluctuating comportments estimation round the medium values.

The test engine comportment modes at fueling with mixtures resembled, proving minor dependencies by the type of oil used. For illustration, the evolutions of the developed engine torque at the power shaft and of the specific fuel consumption, in the conditions of fueling with mixtures of rape oil and diesel fuel, are presented in **Diagram M** and **Diagram c** from below.

DIAGRAMA M. Developed torque evolution at the power shaft at fuelling the test engine with diesel fuel and mixtures containing 10%, 20% and 30% rape oil

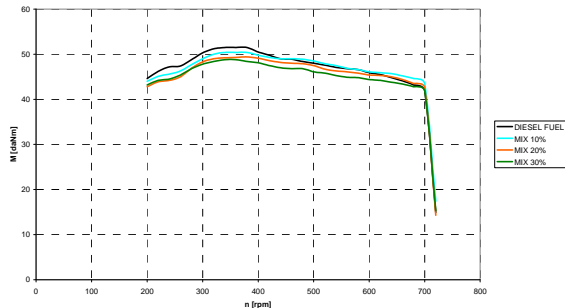
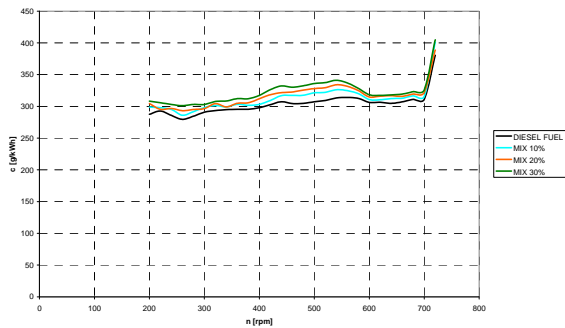


DIAGRAMA c. Specific fuel consumption evolution at fuelling the test engine with diesel fuel and mixtures containing 10%, 20% and 30% rape oil



The aspects from diagrams indicate a good comportment of the test engine by the performances point of view. There are remarked, in case of mixture containing 10% vegetable oil, even increments of the engine momentum for some rotative speed regimes which, in principle, could lead to indicate improvements of the burning process. Regarding the specific fuel consumption evolutions, these ones reflect, in a predictable way, the power increments corresponding to the mentioned momentum increments.

ASPECTS CONCERNING THE POTENTIAL AFFECTATIONS OF THE ENGINES TECHNICAL STATE

The tests from above were marked by a technical incident of which uniqueness does not allow the verdicts issuance but which, by the recorded aspects with the occasion of the re-enabling intervention, could suggest some reserves looking the practice of fuelling the Diesel engines with diesel fuel - raw vegetal oils mixtures.

The cumulated period of tests with mixtures diesel - vegetable oil was of approximate 110 hours in which the engine functioned at full load. After this period, the engine has presented an apparently sudden loss of the tightness between the burning chambers and the crankcase, indicated by the apparition of a violent flux of burning gases through this last one. At the re-enabling intervention of the technical state, which has presumed the engine strip down, it was established as main cause of the reminded manifestation the total loss of the tightening segments function at the engine's cylinder 1 piston, because of the abundant deposits in the segment channels (figure 1).



Fig. 1. Deposits which invalidate functioning of the air tightening segments

The examination of the other engine components has revealed an unpermitted abundance of deposits on the pistons ends, in the superior areas of the cylinders casings (figure 2), in the cylinder cover areas which correspond to the burning chambers and to the escape valves heads and in the areas in which the injectors peaks are entering the burning chambers and on the injectors peaks (figure 3).



Fig. 2. Deposits on the cylinders casings



Fig. 3. Deposits in the injectors taps and on their peaks

Even if those aspects cannot be generalized, because we are talking about an unique set of tests, they are drawing our attention on some potential barriers in front of the usage practices of diesel fuel - vegetal oils mixtures as an alternative solution of fueling the Diesel engines built for fueling with diesel

fuel. It's proper here to make the comment that the used oils were subjected to an initial deguming process effectuated at the level of which this operation is required in the producing industry of the vegetal oils for food purposes.

CONCLUSIONS

The tests results indicate as possible the practice of fueling with diesel fuel - raw vegetal oils mixtures the Diesel engines built for fueling with diesel fuel, with the condition that the used oils to be subjected to a total removal treatment of the components generic identified under the name of "gums". On the other hand, the study of the physical properties of the used mixtures and their comparison with the diesel fuel ones reveals viscosity increments which suggest the effectuation of researches regarding the influences of its measure on the injection equipments endurance.

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