VEGETABLE OILS, ALTERNATIVE ENERGY SOURCE WITH WIDE USE IN VARIOUS FIELDS

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ABSTRACT

The development of alternative fuel production using new non-biomass and non-fossil resources represents a basic concern for promoting new renewable energy sources in order to reduce fossil fuel consumption and greenhouse effect. Knowing the physical characteristics of vegetable oils in general, and those of rapeseed and camelina seeds in particular is useful for specialists and workers in the field, both for assessing the technological and functional parameters of the equipments, which ensures obtaining them and to establish the technological parameters of the purification process.

This paper presents the importance of obtaining and using vegetable oils as biofuels. From the start, in any moment, does not arise the problem of using oilseeds, necessary to obtain food oil, for biofuels. Romania has a sufficient land fund for cultivation of agricultural areas with specific oilseeds for obtaining biofuels, particularly rapeseeds and more recently camelina seeds (biokerosen).

The condition to have success and a considerable benefit is that the oil should be obtained from own production and by their own means, in this way you can capitalize very well the by-products represented by the resulting pellets and oil yeast (impurities loaded with oil recovered from filters or from settling tanks), which is an excellent protein feed for cattle, pigs, sheep, poultry, or top quality solid fuel which has the advantage that it can be used in thermal plants with automatic feeding.

INTRODUCTION

Considering that energy requirements are increasing and that fossil fuel reserves are depleting and polluting effects of their use are catastrophic on ecosystems, it became necessary to find new ways of producing energy from alternative sources to replace these classic fuels. Serious increase of air, water and soil pollution, which contributes to the deterioration of public health, global warming, which is already causing catastrophic climatic change, threatens with change of conditions that make life possible on our planet, the high degree of pollution and the high prices of fossil fuels bring to the fore biofuels and sources from where they are produced.

Close exhaustion in time for known reserves of natural gas, oil and coal, which resulted in continuous and rapid increase in prices in the last thirty years, their price on the world market will make in a few decades, to disappear the current main economic sectors. Attempts to use vegetable oils as fuels are older than internal combustion engines. "Biodiesel" can be reduced by 70% net emissions of carbon dioxide compared with petroleum-based fuel, thereby reducing gases which produce greenhouse effect, those that result in global warming. "Biodiesel" is a processed fuel similar to ordinary used in diesel engines. It is synthesized from biological sources (vegetable oil) and can be used in unmodified diesel engines. But here we must distinguish between Straight Vegetable Oils - SVO or Waste Vegetable Oils - WVO used as fuel in some modified diesel engines. Biodiesel is composed predominantly of alkyl esters obtained by trans-esterification of vegetable oils or animal fats.

"Biodiesel" is biodegradable, non-toxic and generates significantly less dangerous pollutants such as NO_2 or SO_2 than the classic fuel (diesel) when is burned. Although Rudolf Diesel used as fuel for engine prototypes vegetable oils known nowadays such as peanut oil, sunflower, rape oil or soybean oil, with the generalization of using diesel as fuel, the idea that we might use something else as fuel for diesel engine has no longer been in the sphere of concerns of car manufacturers.

With the awareness that over 2 generations of mankind has burned successfully, but also aimless, 80% of the planet's oil resources, dramatically accentuating environmental problems, Diesel's idea was again brought into actuality. Is looking for new sources of fuel substitution and use of classics mixed in various proportions without influence on engine components. It will also put a strong emphasis on food security by detecting and using those resources that do not affect it. In this sense it will place great emphasis on use of unused vegetable oils in the population nutrition: oils obtained from high erucic acid rapeseed, camellina oil.

MATERIAL AND METHOD

Seeds processing in recent years experienced significant progress in the endowment with advanced machines and equipments. This fact was dictated by qualitative development through a continuous improvement of process technologies. Therefore obtaining vegetable oils require technology upgrading using advanced technical equipment to ensure the production of high quality products.

Knowing the physical characteristics of the vegetable oils that are to be obtained and used as biofuel, is useful for assessing the functional and technological parameters of equipment that ensures obtaining them and for setting the technological parameters of the purification process. Pure vegetable oil is obtained from oil installations through pressing, extraction or comparable procedures and may be pure or refined, but not chemically modified. It can be used as biofuel, when is compatible with the type of motor used and meets the requirements of emissions in the environment.

One of the methods for obtaining vegetable oils is by cold pressing. An advantage of cold pressing for oilseeds is that, besides producing vegetable oil, there is obtained valuable fodder cakes used successfully in animal husbandry. The level of seed production is extremely important, decisive for the profitability of the entire system: by the amount of seed obtained per hectare; by the percentage of extractable oil and the by the possibility of using cakes resulted from extraction for livestock feeding. The crude oil can be used directly in engines up to 100% in summer, with an addition of 40% in autumn and in low concentrations due to the different viscosity of the oil in winter.

1. Seeds pressing

Pressing is the operation by which is separated the oil from the oilseeds of oleaginous plants under the action of external forces, which result in crude oil and grist (cakes, pellets).

At first, is separated the oil retained on the surface of the breach particles which flows through the channels between the particles, and when under the influence of increased pressure the deformation and compression of particles starts, it occurs the oil removal. When the space between particles becomes very small, the oil is no longer removed and the grist is formed (cakes). Modern presses have more chambers for pressing; the briquetted structure (cake) takes the form of the extruder through which is discharged.

Increasing the pressure on the raw material (oilseed) must be gradual because otherwise the milled fine particles clog the capillaries and block the discharge of the oil. The pressing can be considered a filtration through capillaries, phenomenon that is expressed by the relation [1]:

$$V = \frac{®Pd^2}{128¦l}[m^3] \quad (1)$$

Where: *V* is the volume of separated oil, in m³; *P* is the applied pressure in daN / cm²; *l* is the length of capillary, in m; *η* is the dynamic viscosity, in Ns/m²; and *τ* is the duration of applied pressure, in s.
Oil separation process is positively influenced if the *P*, *d* and *τ* values are increased and if *η* and *l* are decreased. The pressing force *P* of mechanical presses is created by a screw which rotates in the pressing chamber. The gradual increase of *P* is ensured by:

- volume decrease from the pressing chamber from one stage to another (by increasing the diameter of the screw and decreasing the chamber diameter);
- reducing the screw pitch;
- through the size and shape of the intermediate rings between screws (only for cold pressing);
- through the resistance at the exit of the material from the "cone" of the press that adjusts the thickness of the material exiting from the press.

Depending on the press, *P* can have values between 250-280 daN / cm² for preliminary pressing presses and presses with small capacity (15-50 kg / h), which executes cold pressing, and between 400-3000 daN / cm² for final pressing presses or cold pressing presses for large capacities (> 100kg / h) [1].

2. Calculation of power needed to operate the screw

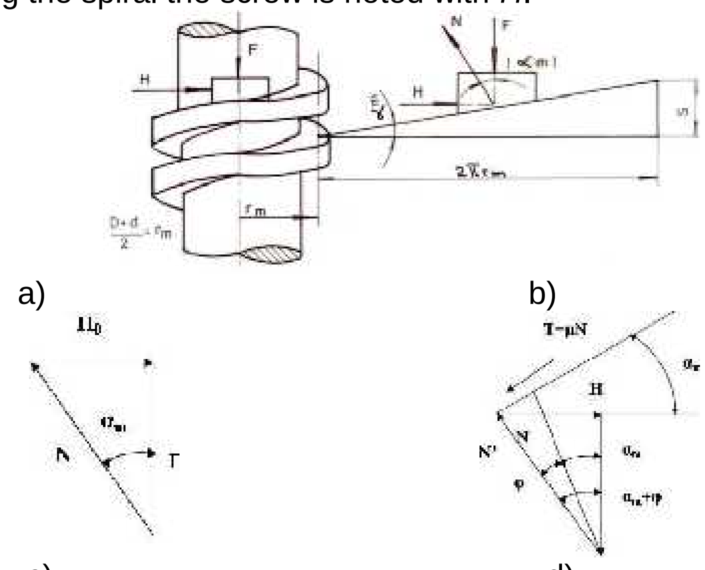
The power needed to operate the screw can be calculated with the formula [1]:

$$P = \frac{M_t \cdot n}{95.500} \qquad (2)$$

Where: M_t is the torsion moment applied to the shaft of the screw, in daN·cm; *n* is the revolution, in r/min and *P* is the power needed to operate, in kW.
The torsion moment is evaluated considering that on the screw acts the resultant *F* of pressure force exerted by the oleaginous material on spiral of the screw (Fig. 1, a), which is calculated with the relation [2]:

$$F = \frac{\pi}{4(D^2 - d^2)p} \qquad (3)$$

Where: *p* is the pressure of the extraction that takes values in the range of 25 to 28 MPa or 40-200 MPa, depending on the type of the press – with one or two sections; *D* is the outside diameter of the screw spiral in the pressing zone and *d* is the inner diameter of the pressing zone.
Force *F* does with the normal to the spiral of the screw (Fig. 1, b) the β_m angle. The force required to push the material along the spiral the screw is noted with *H*.



a) b)

c) d)

Fig. 1. The forces created by the oleaginous material on the spiral of the screw [2,4]

As a result of moving the material by the *H* force it occurs its pressing, developing the axial resultant *F* of the pressure forces, so if frictionless:

$$H = H_0 = F \cdot tg \cdot \alpha_m \quad (4)$$

As shown in Fig. 1, c where *N* is the normal reaction to the spiral of the screw. The friction force results in a deviation of the normal reaction with the friction angle *φ* resulting the resultant *N'* (Fig. 1, d). In this case, between the forces which act we can write the relation:

$$H = F \cdot tg(\alpha_m + \varphi) \quad (5)$$

As a result, in order to achieve the pressing of the material is operated with a torsion moment:

$$M_t = H \cdot r_m \cdot tg(\alpha_m + \varphi) \quad (6)$$

Or of the relation (3):

$$M_t = \frac{\pi}{4}(D^2 - d^2) p r_m tg(\alpha_m + \varphi) \quad (7)$$

3. Calculation of power needed to operate the screw

The drive shaft is the shaft on which is mounted the screw segments. Through the drive shaft is transmitted the movement to the screw. Loading the screw at the time of operation is shown schematically in Fig. 2. On screw acts:

- M_r the torsion moment created by the drive system;
- screw weight uniformly distributed along the length *L*;
- axial load due to transport pressure, p_a.

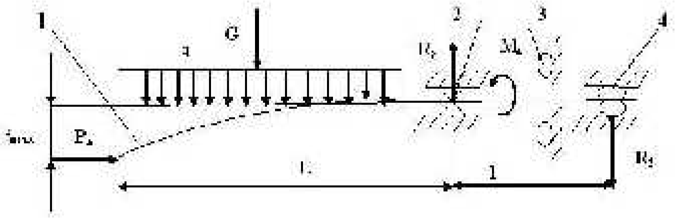


Fig. 2. Loading scheme of the shaft [2,4]
1 - elastic line of the shaft; 2 – the shaft support; 3 - thrust bearing; 4 - roller bearing.

The weight of the screw is calculated with:

$$G = q \cdot L \quad (8)$$

Where *q* is the linear loading of the screw and *L* is the screw length located in the console.
The axial load is calculated with the formula:

$$p_a = \frac{\pi}{4(D_s^2 - d^2)\Delta p} \quad (9)$$

Where: D_s is the outer diameter of the spiral the screw in the feeding zone; *d* the inner diameter of the spiral the screw and *Δp* is the pressure at the end of the screw.

Buckling calculation of the screw. Critical buckling load for embedded bar of length *L* is given by:

$$p_{cr} = 2{,}467\frac{EI}{L^2} \quad (10)$$

Where *I* is the moment of inertia of the shaft and *E* is the modulus of elasticity of the material.

The moment of inertia is calculated using the formula:

$$I = \frac{\pi d_a^4}{4} \quad (11)$$

Where: d_a is the shaft diameter.

It is calculated the effective safety factor with the relationship:

$$c_{ef} = \frac{p_{cr}}{p} \quad (12)$$

In a reasonable dimensioning,

$$c_{ef} = c_a(1 \div 0{,}1) \quad (13)$$

Where: c_a is the admissible buckling safety factor.

Calculation of maximum arrow of the screw. For an embedded bar at one end, with a uniformly distributed load at the free end, the maximum arrow is:

$$f_{max} = \frac{ql^2}{8EI} \quad (14)$$

It is necessary that:

$$f_{max} < \delta \quad (15)$$

Where: δ is the radial clearance of the screw into the cylinder.

It is considered that the screw is a bar subject to bending and torsion. In these circumstances are generated normal and tangential unit efforts.

The maximum bending unit effort. The maximum bending moment is calculated with the formula:

$$M_{i\,max} = \frac{GL}{2} + p_a\delta \quad (16)$$

$$f_{max} = \delta \quad (17)$$

The maximum unit factor is determined by the relation:

$$\sigma_{max} = \frac{p_a}{A} + \frac{M_{i\,max}}{W} \quad (18)$$

Where: A is the area of the shaft section and W is the section modulus of the shaft.

The torsion unit effort. The torsion unit effort is determined by the relation:

$$\tau_{max} = \frac{M_t}{W_p} \quad (19)$$

Where: M_t is the maximum torsion moment and W_p is the polar section modulus of the shaft.

The equivalent unit effort. For the equivalent unit effort, according to the theory of tangential maximum efforts is calculated with the formula:

$$\sigma_1 e = \sqrt{(\sigma_1 max^2 + 4\tau_1 max^2)} \quad (20)$$

Equivalent unit effort is compared with the admissible unit effort, respectively:

$$\sigma_e \leq \sigma_a \quad (21)$$

The duration of the pressing, τ must be sufficiently high to allow the flow of oil. Exceeding the duration does not increase the yield significantly when pressing, but noticeably it reduces productivity. The pressing duration, as the sum of the pressing duration on each section (step) is given by:

$$T_s = \frac{V_s E}{Q_v(1 - \beta_s)} \quad (22)$$

Where: V_s is the volume of free space from the pressing section, in m^3; E_s is the degree of pressing in that section; Q_v is the volume flow of the grinded material, in m^3/s; B_s is the correction factor related to the amount of grinded material removed from the press with oil, up to the section analyzed.

The pressing duration, according to the constructive and functional characteristics of the press, it is 40-200 sec. The pressing duration is influenced by the revolution of the screw, the thickness of the grist on the press output and physico - chemical properties of the seeds. At cold pressing, the screw revolution is between 8-36 rev / min. We use a gear motor with an output shaft revolution of 8.9 or 9.1 rot / min.

Having these data, which are required for us to determine the technical equipment capacity required for pressing the oil plant were established the technological flows for 12 production lines of oilseeds processing with 1, 2 or 3 presses whose pressing capacity are 130-150 kg / h pressed seeds. These may be used to obtain necessary vegetable oil in a small or middle capacity agricultural farm. Depending on the building available to the farmer, the system can operate with vertical or horizontal flow. The horizontal flow are cheaper but pays off in a long time while the vertical flow are more expensive but it pays off in a shorter time and using the gravity force

RESULTS AND DISCUSSIONS

Starting from a scheme with three presses with horizontal technological flow was conceived and realized an installation for obtaining vegetable oils that can satisfy fuel demand necessary for carrying out the activity in good conditions in an agricultural middle farm.

Fig. 3. The Installation for obtaining vegetable oils IEU 450 [2]

The installation for obtaining vegetable oils has a processing capacity of 450 kg of seeds / h and consists of three modules: seed preparing module (inclined conveyor, supply bunker, horizontal screw conveyor, bucket elevator, magnetic separator, rotary separator and intermediate bunker) oil extraction module (frame, feeder conveyor with chain and nods, preheated seed, three oil presses, oil collector) and oil purification module (a battery of four vertical sedimentation settling tanks and a horizontal filter plates, vertical filters).

The work process at the installation for vegetable oils IEU450. Seeds are brought in bulk or in bags and stored in the storage bunker. Its supply is made with inclined screw conveyor. From the storage bunker, the seed mixture is taken over by a horizontal screw conveyor and is inserted the in the elevator bases where it is raised, then passed through the magnetic separator where metal impurities are separated.

From here, by the free fall, the seeds are placed in rotary separator where coarser impurities are separated and from here cleaned seeds are stored in an intermediate bunker. The coarse product is collected in bags and discarded as unusable residue. Stored seeds in intermediate bunker are taken with a chain and nodes conveyor entering the preheater bunker.

A part of the hot air temperature passing through the serpentine is transmitted to oil plants seeds (rape, sunflower, soybean, castor oil, etc.), which will help to speed preheating pressing process.

From preheat bunker the seed through a cylindrical tube supply three presses with seeds. Depending on the amount of seed to be processed is using one or even all 3 presses. Once the seed reached in the press feeding cone are taken over by the power segment from feeding chamber. Before loading the press is imperative that it be heated, especially the extrusion head. In this sense the press will run dry between 3 to 5 hours depending on the environment temperature. The press is prepared taking into account the type of seeds to be processed, showing the specific settings for each type of seed. Seeds from feeding chamber are taken by the feeding screw and placed in the press chamber. Pressing takes place gradually. In the first segment takes place seeds breakage and eliminating some smaller oil and further takes place shredding, grinding seeds and oil removal.

A small amount of oil will remain in the mass of the grist, the quantity can vary from 5%-8% depending on the type of seed and adjustments made. The grist is removed in the pellets form (rapeseeds, flaxseeds) or in cakes form (soybean, sunflower). Can be obtained only as pellets but ensuring a rigorous control. The advantage of obtaining the pellets form is that it is easier to store and easier to use as fuel.

During the use, the press will work with mounted side guards being removed the danger of spreading the oil. From the press, the oil is discharged through a funnel which collects oil from all pressing segments and introduces it into the oil collector. In order to avoid phospholipids deposited on the walls, the oil collector is provided with a mixer which is driven by a motor gear that provides a frequency rotation of about 20 rev / min. Oil collector capacity is chosen so as to ensure the collection of oil from the three presses in 24 hours. The pellets discharged from the press extrusion head fall into pellets collector, where when it is almost full is emptied, the pellets are collected in a special place.

From the evacuation pellet chamber, the temperature obtained after processing of seeds is taken over through a flexible plastic tube with a metal insertion by a radial-axial fan and sent to preheating bunker seed. From the oil collector through the fittings provided at its base with the help of a centrifugal pump the oil will decant into decantation-sedimentation tank. They form a battery, the first through an overflow supplies the second, and so on. Before going through the overflow every tank has one sieve whose mesh grill decrease from the first to the last tank from 630 to 160 µm. They are designed to retain coarser impurities and some part of phospholipids.

a) **b)** **c)**

Fig. 4. Raw material and products obtained after cold pressing
a – raw material (rapeseeds); b - pellets; c – vegetable oil;

The coarse product deposited at the bottom of the tank is discharged on their base. The decanted product from tank is pumped and placed in horizontal filter with plates where coarse unseparated impurities are retained into decantation-sedimentation tank. The filtered product if has the required purity is collected in tanks. Otherwise it can be switched to a fine filter with vertical filters. From here pure product is stored in finished product tanks, where it is taken over and used to power tractors and self-propelled farm equipment under which they serve. In case when not qualify as fuel, even after this filtering, it will be subjected to chemical treatment in specialized facilities for producing "biodiesel", but which are expensive to delivery to a small or middle sized farms. The characteristics of biofuel and the diesel fuel are shown in Table 1 [3].

Table 1. Characteristics of biofuels and diesel

Fuel type	Caloric power [kj/kg]	Density at 15^{0}C [g/cm^3]	Kinematic viscosity at 40^{0}C [mm^2/s]	Cetane number	Flammability point [^{0}C]
Diesel fuel	42100	0,832	2,00-4,50	49,2	62
Rapeseed oil	37700	0,885	46,00	45,3	153
Camelina oil	39270	0,916	32,67	-	170
Sunflower oil	38525	0,910	45,00	40,3	195
Corn oil	37800	0,906	41,00	41,0	236
Soybean oil	39252	0,901	40,00	40,8	205

The use of vegetable oil: The crude oil cannot be used when the engine starts. To ensure this, the start will be on diesel, oil heating being made through an adapter. When the oil has reached the required temperature (70-80 °C), it run manually or automatically, depending on the timing, on raw vegetable oil feeding. The power scheme of a classic diesel engine fitted with adapter for use with crude oil from oilseeds (rapeseed, camelina seeds) starting on diesel, is shown in Fig. 5. [3]

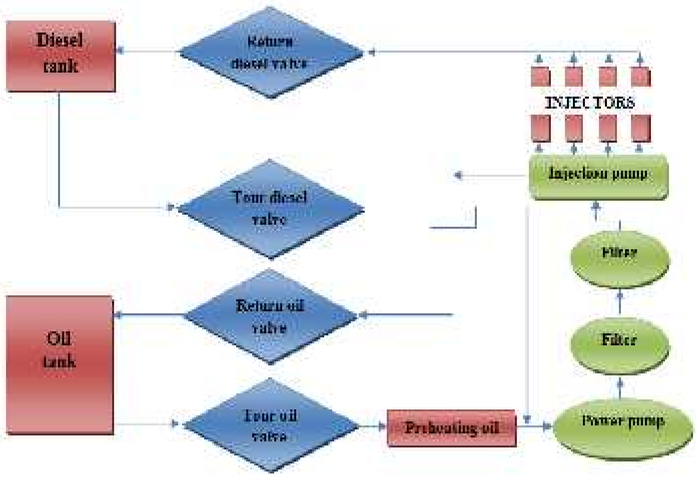


Fig. 5. The power scheme with vegetable oil for diesel engine

When engine stops it's proceeded backwards: first we interrupt vegetable oil feeding then passes on diesel. Is allowed to operate on diesel a equivalent time with the full consumption of vegetable oil on the route. The feeding route will remain full only with diesel.

CONCLUSIONS

The phenomena that occur in the process for obtaining oils with presses are very complex. The quantity of oil obtained depends largely on the nature and quality of the oleaginous material which is pressed.

From existing specialized studies is noted that the geometry and mechanical characteristics of the current presses were obtained using experimental determinations, the results underlying the improvements that have led to their performance.

An accurate assessment of pressures and pressing forces is heavy, imposing, rather, their experimental determination. To explain the phenomena of flow and sizing extruders (exhaust nozzles) is necessary to know the coefficient of dynamic viscosity and other coefficients, imposing for that the development of experimental determinations. The vegetable oils production installation presented, provides the necessary of biofuel needed to power tractors and self-propelled that serve a middle farm of 600-900 ha.

The use of crude vegetable oil as fuel for diesel engines, has a number of advantages, some of which are worth highlighting: it is a renewable fuel; relatively easy to obtain direct to the consumer; lower cost price of 1.2 -1.4 times compared to diesel; reduced pollution (sulfur compounds virtually absent from flue gases); high operational safety. The crude oil cannot be used when the engine starts. To ensure this, the start will be on diesel, oil heating being made through an adapter.

The use of crude vegetable oil as a fuel in the long run, it is recommended only when the engine is working under load respectively at a revolution of 1000 rpm. At idling the oil has no complete combustion and can leak besides pistons in the engine oil pan and causes polymerization (oil becomes gel). To remove this impediment is necessary to use a cogeneration unit, the motor run continuously under load, so at high revolutions.

This cogeneration unit corrects the oil viscosity using a device that performs controlled heating of the oil up to a temperature of 700 – 800 ^{0}C, temperature at which the raw oil reaches classic fuel parameters. It is necessary adaptation (conversion) of diesel engine to run on vegetable raw oil. In this situation, the engine starts on classic fuel (diesel) and when oil is heated at operating temperature (800 ^{0}C) automatically switches to vegetable oil. Starting the engine on diesel is required by the vegetable oil flammability point greater than (200 – 230 ^{0}C) than the classic fuel (620 ^{0}C).

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