2nd VegOil

Demonstration of 2nd Generation Vegetable Oil Fuels in Advanced Engines

Workpackage 3

Fuel development

Deliverable N° D3.10: Reference press III

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1. Summary

According to the modified workpackages as described in the 1st Amendment to the Grant Agreement, ITP (previously IBMER) was incorporated into the implementation of WP3 *Fuel development*, Task 3.10: *Set-up-of third reference press in Poland.* Researchers from ITP started to work on this task in early 2009. The first small scale attempt to manufacture 2G-PVO from rapeseed oil fuel was carried in April 2009 and in June 2009 and first promising (while not yet fully satisfying) analytical results were obtained. The next step was the transition of oil production from laboratory to larger-scale which was taken in October 2009. The first batch of about 500 l produced in this larger scale, was ready in June 2010, next ones in August 2010 and September 2010, 1300 l in total. The oil parameters met all requirements of the 2G-PVO standard except for oxidation stability and acid value. As further investigations and results of corresponding analyses by ASG Analytik Service showed these problems could be solved by using anti-oxidants (E 301 and E 302) and better seed quality. ITP will ask for the right to start oil production with the 3rd reference press to the end of 2010 at the latest.

During 2011 additional 1 000 l of rapeseed oil was produced. Laboratory tests made by Chemical Laboratory of Technical University in Poznan showed that purifying technology is OK and the resulting product comply the Norm requirements.

Late summer 2011 small amount of corn and sunflower raw oil was subjected to a purification process by Polish technology. Laboratory Institute of Biotechnology in Warsaw, Poland test results as well as test results made by ASG Analytik Service in Germany indicated discrepancy with expectations. Further research to improve technology production of fuel from other than rape seed will be continue in ITP. One problem is that corn and sunflower seeds are not popular in Poland and probably never will be base material for liquid fuel as rape is.

2. WP 3, Task 3.10, Set-up-of the third reference press in Poland

2.1. Fuel oil production on an laboratory scale

The laboratory tests started in January 2009 and were completed in May 2009. The optimisation of the fuel production process was prepared by studies and laboratory tests done by scientists of the Poznan branch of the Institute.
The very first attempt to manufacture rapeseed oil fuel has been taken in April 2009. Five attempts with different purification conditions were made with 50 l of oil each batch. The oil samples were sent to the laboratory of the University of Poznan for chemical analysis.
Sample No 1 – Both filter purification;
Sample No 2 – Chemical additive full dose
Sample No 3 – Both filter purification, lower pressing temperature
Sample No 4 – Raw Oil
Sample No 5 – Chemical additive half dose

The analysis results indicate that the basic parameters of the pressing process, the mechanical and chemical purification technology are correct. At this stage of research oxidation stability and water content of oil have not been investigated.
Second attempt in laboratory scale. Using the same technology, as sample No 3 above, an additional batch of app. 100 l of rapeseed oil was made in June 2009 and sent to the ASG laboratory for a full analysis. Results are shown in Figure 2 in the annex.
For the first time, in addition to the contents of the elements Ca, Mg, P, all parameters were examined in accordance with the DIN 51605 requirements. The water content was exceeded and the oxidation stability at 110 °C did not match the DIN 51605 requirement.
The third attempt for 2G-PVO production was made in October 2009 paying more attention to seed quality. An oil sample was sent to LUBRIZOL for analysis. All parameters were achieved except the oxidation stability. In effect the production in a larger scale was initiated. The work in the laboratory scale was carried out simultaneously to improve the oxidation stability of the product.

2.2. Transition to production at demonstration scale

The positive results of the laboratory analysis made it possible to manufacture in demonstration scale. This lead to a production line consisting of the following components:

- oil extraction press for cold pressing with dual working elements with a capacity of 35 kg/h each;
- set of filters, in this buck filter and sleeve filter;
- mixer for final oil purification;
- grain feeding system.

First larger batch of oil – ca. 500 l - was made in June 2010 with the same technology. One sample was sent to ASG laboratory. The report of the complete test (annex, Figure 4) confirms the expectation, inter alia:

- P+Ca+Mg under 3.5 mg/kg
- Water content under 750 mg/kg

The oxidation stability at 110 °C was still too low. After consultation with partners the decision was made:

- to pay more attention to the raw material rapeseed quality, especially to level of desiccation,
- to chose an appropriate chemical additive dose.

Next batches 500 l (August 2010) and 800 l (September 2010). Oil samples were sent for analysis to Laboratory Institute of Biotechnology in Warsaw and to ASG Analytik Service (annex, Figure 6). The results of the analysis made by the laboratory of Institute Biotechnology are satisfactory, including the oxidation stability. Although it was decided not to take them into consideration as the analysis methods of that laboratory were not accredited..

The results of the analysis by ASG are reliable. They confirm the correctness of the technology used for providing oil parameters including:

- oxidation stability 110 °C over 6 h;
- water content under 750 mg/kg;
- P, Ca/Mg content under 1.5 mg/kg.

The present test indicates a high content of total contamination. The reason for this is that the personnel on the production line did not change or clean the filters. Therefore this problem was solved already.

2.3. Rapeseed oil pressing and filtration

Oil pressing. The oil is cold pressed using a press factory without structural changes – screw press FARMET-DUO (Czech Republic made)

dimensions (mm): 500x1360x860
weight: 150kg
supply voltage: 400V

power consumption: 2,2 kW
productivity: 18 - 25 (seed kg / h)
residual fat in cake: 13 - 15 %

The production line was obtained, with a capacity from 460 to 1550 litres of oil per week, depending on the system of work, continuously.
The following parameters are subject of the rapeseed analysis: moisture content, pollution and determined level of the oiling. Recent results of the analysis adopted in oilseed rape are (in average of few batch). And results of operational testing presses from rapeseed oil, as described above as well:

Seed amount [kg]	Moisture content [%]	Pollution [%]	Oil content [%]
6 700	**7,3**	**1,2**	**43,9**
Extrusion time [h]	Amount of oil [kg]	Amount of cake [kg]	Level of extrusion [%]
171,7	**2 034,8**	**4 658,2**	**29,8**

:

Extrusion temperature (measured on the press head)	$60^0C \pm 5^0C$
Ambient temperature:	$18 - 25^0C$
Oil temperature immediately after leaving the press head	$31^0C \pm 2^0C$
Cake oil content	20% ± 2%

Oil filtration.
Filtering devices:

- Buffer tank 150 dm^3 equipped with weigh;
- Cylindrical mixertank 700 dm^3, mechanical stirrer 130 rpm, 2 propellers diameter of 300 mm each. The final purification mixer is the original design of the Institute's scientists .
- Filter plate – 9 plate interspersed with synthetic mesh
- Fine cotton filter – 1.3 m cotton sleeve .

Filtration technology:
The raw oil goes from the press to the buffer tank for the first stage of sedimentation and to decrease the oil temperature. After few, depending on ambient temperature, oil is pumped to the mixer tank where the chemical additives are added. All the liquid is being mixed for 2 hours and then goes on the filter plate. Filter bandwidth is 38 l per hour.

Prevent oxidation:

After filtration on the plate filter the oil goes to the buffer tank again, where antioxidant is added. Directly from the buffer tank the oil goes to the cotton sleeve filter for final cleaning. Filter bandwidth is 100 l per hour. The purified oil is stored in a 1 000 l tank.

The oil cake is used as animal feed. Process residues (of filtration and sedimentation) are added to the manure and exported to the fields.

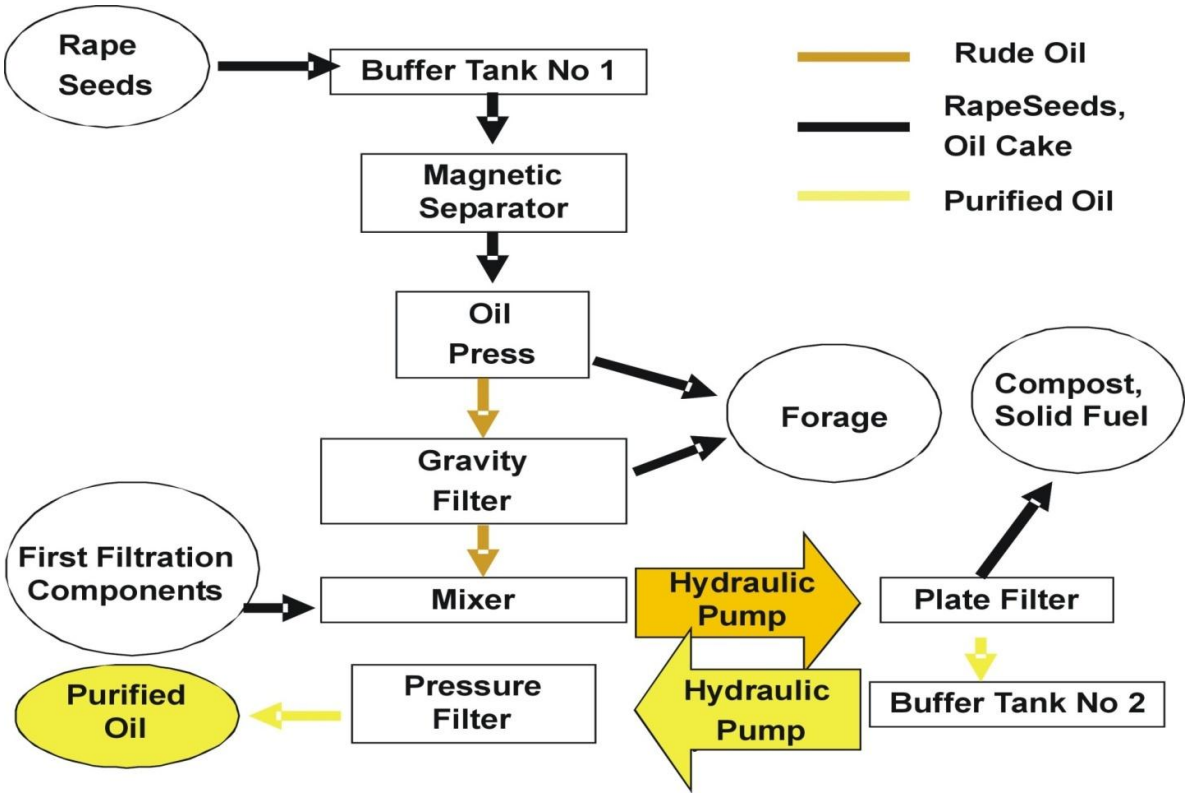

Figure 1: Simplified description of a decentralised oil mill for PPO production

2.4. Main factors influencing vegetable oil quality

Past experience showed that there was the significant correlation between factors:

PARAMETER — INFLUENCING FACTOR

- acid value → seed sort, seed age, seed moisture
- oxidation stability → seed sort, seed age, seed moisture, oil purifying
- water content → seed age, seed moisture
- purity → seed age, oil pressing, oil filtration

- P, Ca/Mg content ⟶ seed sort, seed fertilization. oil pressing, oil purifying

Oil storage conditions and storage times had clear impact on water content, and oxidation stability. But production system for farmers own needs does not provide to long time of fuel-oil storage.

2.5. Expectations and intensions

It has to be emphasized that polish farmers owning John Deere 2ndVegOil demonstration tractors (at this moment one of them) will continue to use the 2G-PVO-powered tractor after the completion of the Project using the fuel produced by own Polish technology.
The technology has been the subject of Utility model application at Polish Patent Office.

Attempts to produce fuel from oilseeds other than rape seeds should be regarded as unsuccessful. Leadership Institute decide to continue investigation on adaptation of technology to make fuel from other oil seeds as camelina, corn, sunflower. But was is very important rape will be in Poland the main raw material to produce oil for engine oil purpose as pure plant oil or methane ester.