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Title: Experiences with Jatropha oil conversion technologies, Mali, Mozambique, Honduras and Tanzania

Prepared by: Thijs Adriaans & Jan de Jongh for FACT

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FACT Foundation

FACT promotes the development and use of
bio-fuels in developing countries for local people

FACT Foundation
Horsten 1, 5612 AX,
Eindhoven, The Netherlands
Phone: +31 40 2472311
Fax: +31 40 2439475
Email: info@fact-fuels.org
Internet: www. fact-fuels.org

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Introduction

As part of the FACT project “Knowledge Exchange Mali, Mozambique, Honduras” a one day Seminar was held in The Netherlands on the 25th of September 2008. The purpose was to exchange experiences of conversion technologies, applied in the FACT pilot projects that are presently half way in Honduras, Mozambique and Mali.

Also Tanzania was included since Diligent Tanzania is related as a partner to FACT and is ahead of the project regarding conversion technologies.

It concerns the subjects: Bio-fuels, oil pressing, oil processing, diesel engine modifications and testing and bio-diesel.

Persons involved in this subject, mainly with technical background, were invited and the following persons participated:

Niels Ansø (Dajolka, DK)

Thijs Adriaans (Ingenia, NL)

Joost Fokkink (Biofules bv, NL)

Ger Groeneveld (PPO Groeneveld, NL)

Titus Galema (STRO Foundation, Honduras)

Peter Moers (STRO Foundation, Honduras)

Peter Beerens (NL)

Mara Wijnker (FACT, NL)

Jan de Jongh (FACT-Arrakis, NL)

Also Thomas van der Heijden, active in Tanzania and Sander de Waal, from BRODTECH (supplier of diesel engines for Mali project) were invited but regretted that they were not able to come.

Presentations in powerpoint were given by:

Joost Fokkink, Ger Groeneveld, Titus Galema, Peter Beerens and Jan de Jongh, while minutes of the meeting were made by Thijs Adriaans, which follow hereafter.

The powerpoint presentations can be found on the website of FACT: www.fact-fuels.org

Minutes of Meeting

All participants gave a short introduction of themselves.

Niels: mechanical engineer, specialised in PPO, from Dajolka (formerly Folkecenter), currently working for Honduras (Gota Verde) and Mali Folkecenter

Thijs: project engineer at Ingenia, working on renewable energy for Dutch/European industry and for FACT

Joost: educated automotive engineer, worked for Wärtsilä and OPRA, works at HoSt, represents Biofuels BV

Ger (entered at 11.30h): doing testing and production of biofuels. Physics Engineer, supporting both projects in Honduras and Mozambique.

Titus: permanently based in Honduras for STRO foundation. Studied at Larenstein hogeschool.

Peter Moers: regional coordinator South-America for STRO. Background in economics.

Peter Beerens: graduated at TU/e on jatropha pressing research, currently looking for a job.

Mara: works at the FACT office and documentation center. Background in human technology interaction.

Jan: representing FACT-Arrakis, working as a team member of FACT. Specialisms water and energy

Niels Ansø (Dajolka)

Not been to Honduras yet, flying next week (difficulties with getting the parts).

Worked in Denmark with PPO for 10 years. From 1999 workshops for car conversion, cold pressed oil from Germany. Seen the whole development, many challenges in all disciplines. Proven technology is essential, for both oil production (pressing, filtering) but also engine conversion etc. Going to install Elsbett technology on four cars (Japanese make, IDI engines) in Honduras: expensive but proven. Conversion will be done together with a local vocational school. People should get to understand the concept that is implemented in the Elsbett concept and later develop their own tailor-made conversions based on local circumstances.

Jan: care must be taken that the technology must be used afterwards and not be a white elephant.

Peter M: how about spare parts? They are normal parts, only the injectors are special. Glow plugs and filters are usually standard parts. The heat exchanger usually lasts a lifetime.

Titus: we have a car there running on WVO, converted with local parts, running nice.

Joost: with a two-tank system you are less vulnerable for plugs/injectors etc. Thijs and Niels prefer 1-tank if possible (fail safe etc.). Niels argues that cost for these 'pilot' vehicles is not so much higher, Elsbett would even be willing to support local production.

Peter M: Niels, do you have experience with WVO? Yes, some. Some Danish people use the liquid fraction or the semisolid phase. Some cars were converted to 2-tank with PPO in the first tank and WVO in the extra tank, hose-in-hose fuel lines. Honduras frying oil is usually soy or refined palm oil, it remains liquid except for early morning hours in the mountains.

Fuel quality is essential! Phosphorus, acid number, etc. ASG, a leading German biofuels laboratory, is willing to transfer knowledge to make Mali Folkecenter knowledge centre for West-Africa. Jan tells that Diligent Tanzania is setting up an own laboratory as a knowledge centre for East-Africa.

For rapeseed harvest time has direct influence on quality. For jatropha this is unknown. Joost: tested a sample of JPPO from Honduras seeds. P = 18 mg/kg, acid number 10 mg/kg, oxidation stability 10 hours. Press was about 60-65°C. Seeds might have been ripe or unripe, homogeneous colour. Only the sample of oil was in the kitchen under unfavourable conditions for some months.

Participants suggest testing the seeds of different colours for their composition and oil production and quality. Both yellow, brown and black seeds are accepted from STRO in Honduras. Unripe seeds contain less oil.

Economically all the seeds should be picked (no selection on color). The quality of the oil will reduce then. Usually P, acid number and oxidation stability go together if storage is unfavourable. If oxidation stability is good but the others bad, the seeds may have been unripe (following rapeseed analogy). Optimum harvesting moment should be determined!

Peter Beerens

Graduation presentation: Screw-pressing jatropha oil for fueling purposes in less developed countries (13-08-2007).

His experiences with a company in Madagascar show that all aspects have to be considered from agriculture to collection, cleaning, pressing and refining.

Joost: is there consensus on the yield per hectare? A wide variation is reported, average might be 2 ton/ha seeds. There is huge variation with location, age etc.

Titus: selection by growing plants is time consuming. Can selection for frost-resistant varieties be made by freezing the seeds? Nobody knows. This is a recommendation for further research.

Peter explains the working of the screw press. First intervention possibility: treatment of the seed. Heating has little effect (about 1%) and boiling/steaming is effective but requires energy (moisture and heating are both important). (Joost: castor seed has to be cooked to give any oil.) Pre-crushing has little effect. Asian (Tinytec) setups have a boiler but this works bad for Jatropha. Wet seeds give a paste that rotates without pressure build-up.

Second possibility for intervention: press design. Either press speed, nozzle opening etc. or design a new press. Wageningen University is working on this now.

Independent variables in pressing: screw speed, restriction size, hull content, moisture content, cooking.

Dependent variables: oil recovery, temperatures, pressures, throughput, energy requirement, oil point pressure (start of flowing of oil from the cells). Screw speed influences time perspective: lower speed gives longer residence time and higher pressure, but less throughput. The hull content is related to fibre content. Too little fibre gives a paste without pressure build up.

Cylinder-hole press: constant diameter screw, lower capacities, higher pressures.

Strainer press: increasing screw core diameter, better oil quality, lower T/p, higher capacities.

Energy requirement for pressing is about 5%-10%. Niels: rapeseed 100-150 kWh/tonne clean oil (FC report).

Peter gives an explanation on experimental setup Eindhoven and Tanzania, on Soxhlet extraction and on his results. Three samples of oil were tested at ASG via Ingenia. Two of these show only small deviations from the rapeseed PPO standard. Would this oil be usable in an engine? Niels: it would not break down immediately but is less optimal. Niels had this experience himself with high-P oil, the engine ran less smooth. Acid number is more of an acute danger to the injection system. P is more important for exhaust emission values, catalyst, particle filter etc. Post-treatment would be possible but should be avoided for simplicity.

Foots (sediment): 30-50% vol. that contain 50-55% oil, huge compared to rapeseed cold pressing. Normal filtering equipment is not suitable for this foots load. No correlation between the hull content and the foots load (more or less random, both in Eindhoven and Tanzania).

Niels suggests a chamber press filter. Jan: Tanzania uses bag filters first and then pressurised filters. AMA suggests mesh inserts instead of fabric.

Titus: is there a relation between press temperature and foots? This is unknown but would be worth investigating.

Niels: the Danish Hybren press has a perforated metal sheet as an internal filter. Nice result with rapeseed, only sedimentation is enough (no filtering required). Niels had a quick test done with jatropha seeds, for these the screw has to be changed. No results as yet. Like many Danish small producers of oil and/or equipment Hybren is suffering from high seed prices.

Ger: a continuous centrifugation process ($ 500 investment) is interesting. Joost argues that this is only an acceleration of the sedimentation process: there is still a wet cake discharge, so still much oil in the cake. Probably not a sufficient solution.

Titus: Is it worthwhile to recycle the sediments in the presscake/seeds? Peter B: too low friction is a problem and capacity is reduced accordingly. Ger: try boiling it off with water.

Reinartz and Keller/KEK achieved about 90% oil recovery with untreated jatropha seeds. High temperature (wear of the machine), high foots content (20-50%). Diligent bought two KEK presses.

Conclusions: there is always a trade-off between settings. Most seed pretreatments are too costly to be efficient. More oil yield also means more sludge. Recommendation: look at the whole production chain instead of only the press, getting high amounts of clean oil is the challenge! The solution should be suited to the situation (KISS), not necessarily as efficient as possible.

Joost Fokkink – Biofuels BV

Local production and use of a cylinder-hole type oil press in Honduras for the Gota Verde project.

Sells presses from Täby and his own make filters and seed cleaners.

Gota Verde WP4: Knowledge transfer on processing oil technology

Locally produced press is basically Täby design. No license, no copyrights. No commercial intentions.

Design considerations:

- easy to produce locally (with good tools, like a technical school would have, and good materials – this would not be possible in Mozambique but works in Honduras)
- cost effective – $ 2000 est. price, 25 rpm and 8,5 kg/h seed
- start from a working concept (Täby T70: screw pitch constant, best angle on large screw, largest pressure). Why cylinder-hole type? Familiar, proven results. Strainer type may have better cards (adaptable, high capacity) but cylinder-hole suits fine for this project.
- easy to replace worn out parts,
- easy modifications without remanufacturing all interfaces

Changes: press tube divided in two parts and straight sleeve. Tight tolerance for a start (0,2 mm), can be increased.

Jan thinks about pressing in the field to leave the cake there. Titus and Joost consider this rather high-tech.

Press is made locally. Cheap bearings in seed chamber. Press section made locally but elsewhere. Be careful with standards (metric/empirical)!! E-motor 2 kW, reductor, 25 rpm on the spindle. No frequency convertor, speed regulation should be done by changing pulleys. Torque too high -> deformation -> repaired. Seeds remain about entire until the last winding: pressure build up in the last section. Pressure point can be varied a little by moving the press head, but not much. Position of press head doesn't matter. Channels in wall do not transport but prevent rotation of the cake. Channel size varies between European manufacturers.

Peter B: is it desirable to have crush only in the last winding?

Joost: our results were nice. The proof of the pudding is in the eating.

Results of 20-25% clean oil are found by all experts.

Titus: castor pressing gives oil already at other holes.

Joost: oil escapes only at the last holes. This is confirmed by Peter B. Extending the screw might be favourable for the oil cleanliness.

Jatropha tested at 25 rpm: 8,5 kg/h seed, 2,7 l/h raw oil: 22,8% clean oil efficiency

Castor tested at 25 rpm: 13 kg/h, 6,2 l/h raw oil, 28,8% clean oil efficiency

The cylinder-hole press is limited because of the central hole. Joost thinks 70 mm screw diameter is about the limit. Multiple units are needed above this capacity. Or convert it to strainer type nozzle by taking a cone in the end. Or increase the screw inside diameter for compression. Hybren decreases the diameter. We could learn from the extrusion moulding world. There are many ways to Rome for this topic.

Now one prototype running fine. Not enough seeds for continuous operation. A nozzle is not required: the coarse/raw manufacturing already gives a restriction. If necessary the press cake can be held back to give more pressure.

Jan de Jongh – Equipment for oil processing

Solution for Bilibiza Biofuel Center in Mozambique based on workshop of Diligent Tanzania

Process steps from field to fust.

Questions:

- Proper supply chain?
- Possibility for obtaining spare parts?
- Technical staff
- High cost – low cost

Diligent Tanzania: 1 shift (10 h) 7 tons per day, 1400 liters/day; 4 presses; 8 persons in workshop and 3 overhead; covered workshop area 7 x 40 m = 280 m^2.

Step 1: cleaning of seeds

On a grate the seeds are cleaned from coarse materials.

Step 2: Sayari press 70-100 kg/hr, oil output about 20%, 7,5 kW power, weight 322 kg.

Selection criteria

Other presses: 450 kg/h Indian press + 2 KEK P0101 presses 100 kg/h, 7,5 kW power (37 rpm), 26,5-27% efficiency (raw oil with 20% sediment).

Step 3: settling for sedimentation: 5 days in plastic water tanks of 1 m^3.

Step 4: crude filtering: 200 µ with cotton bags;

Step 5: fine filtering with 5 µ bags.

Step 6: fine filtering with AMA pressure filter 150 l/hr up to 0,5 µ. (slowest step in the chain) (bag filters, originally intended for safety)

Step 7: storage of end product + pumping to consumers

Laboratory of Diligent Tanzania determines: oil content of seeds, moisture content of seeds, water and particle content of oil, acidity, phosphor content, density, oxidation stability

Mozambique: nearest town Pemba (3,5 h), no infrastructure, no electricity, no money, no skilled people. But enough land, cheap labour ($ 2/day), people eager to learn.

Example farmer's club.

Bilibiza Biofuel Centre: 700 kg/day, 120 l/day crude oil. 100 l/day clean oil.

1 shift of 3 persons + 2 overhead.

BBC workshop layout: floor area 48 m^2.

Cost per liter are high because of personnel. Lot of hand work.

Questions on PPO quality: is degumming and/or neutralisation necessary? If yes, can we not better make biodiesel? How to get economics better? How to make better high efficient, low cost presses, preferably skid mounted?

Second question is doubted by Thijs (definite no). Others doubt that. Joost says, focus on good quality seeds and the rest will follow easily. 'end of pipe' solutions. What is good quality seeds? You are dependent on local circumstances.

Jan has some short movies describing the Diligent Sayari press. Infrared thermometer shows about 52 °C in the middle of the press and 90 °C near the end.

Ger Groeneveld – PPO 500 hour test

Running a Lister 3ST on WVO for 500 hours with a 2-tank system, exhaust gas heat exchanger. 2000 running hours before testing, PD DI engine. 27 HP, 1200 cc. 10 kW, 12,5 kVA generator. Total weight 600 kg, oil sump 5 litres. Power delivery under different temperature ranges. Air-cooled engine, no coolant – use the exhaust heat. Stainless steel heat exchanger of own design. Exhaust 450 °C, automatic constant balance between input (flow increases with power) and output (flow and temperature increase with power). 1,5 m stainless steel, 2 mm wall thickness, 10 mm inside diameter. Made with standard pipe bender. Fitted directly to the exhaust manifold. Electrical Hardy pump (membrane + springs) instead of broken mechanical pump. Two tanks because of ability to hand start it. Running 8-10 h/day. Power delivery 2 kW (4-6 h) up to 10 kW (2 h). Outside temperature 7-23 °C. Synchronous generator supplying the greenhouse and welding machine. Mechanical regulator. Double fuel filter (in series) with water separator.

Separately/before: 350 h PPO without adaptation. Soot test with water tub. Soot production with PPO 50% less than with diesel, somewhat more fatty. 5-7% FFA in the WVO was no problem. Three separate unit pumps.

Mean temperature of heated oil 85 °C. 2 minutes warm up needed before max power possible (at lower outside temperature). Fuel heating with lubrication oil would take too long at startup. Injectors inspected during test: clean. No smoke occurred. No oil consumption with diesel, engine oil enhancement with WVO: probably during starting. Engine oil changing interval 100 hr (normal 500-1000 hr). Oil temperature 110°C, relatively hot because of air cooling. No problems due to WVO, only to age (metal fatigue).

400 litres of used cleaned sunflower WVO and 50 litres of WVO biodiesel. And pyrolysis oil: 8 litres giving only 50% of power, after 6 hours engine stop, total cleaning of injection system necessary.

Chinese Feidong IDI engine (copy of Lister-Petter) to be tested in Mozambique. Brand new. No problems expected.

Titus Galema

Development of biodiesel plant in Gota Verde project. Implementation of new technology in rural areas: training of local people.

Aims of the biodiesel plant: promotion, training, processor building, production (max. 500 gallons/month).

Plant construction strategy: capacity adjusted to current offer and demand; avoiding high investments; local training in building, maintenance and expansion of units; generating technical skills (extra entrepreneurship).

Proyecto Tempate Nicaragua (connected to former jatropha project; Foidl 1998). 1 t/h press from Austria/Germany/Denmark. Project went bankrupt. Farmers had to plant jatropha 4 years without other crops without income. Only financing for first two years.

Current biodiesel plant:

- drying WVO (heating to 100°C under pressure; remove lid; let cool down; next morning drain the lowest 5 litres);
- 150 litres per batch;
- gravity fed drain to sedimentation tank (1 week)
- methanol recuperation
- dry bubble wash (air to sediment the soap)
- multiple filtering system (barrel with different clothes)
- 1000 litre storage and selling tank

Engine of the pump should be EX (legally). New pump was placed to handle more viscous fuel.

Methanol recovery from heated barrel, condensating in copper line. Bubble wash in the same barrel with perforated copper line on the bottom and $ 10 aquarium pump.

Small adjustments made continuously to increase production.

Raw material: Chicken/cow/pig fat, WVO, jatropha/castor/soy

Washing with water (removes much soap but takes a lot of water) or dry (recovers small particles and soap, good methanol recovery required (air circle in methanol recovery is closed)) or chemical with MgSi (reacts and settles).

Quality is not optimal yet: sometimes filter clogging, water in the bottom of the storage tank was sold.

Ageratec may supply technology for next project but is much too expensive for this scale. Enzymatic conversion is being developed but not to market before end of 2009.

Current plant is suited to PPO production and there is no market for PPO in cars (no converted vehicles).

Decision to make biodiesel was because of desire of donors to sell biofuel from the start, and there were no PPO vehicles.

Trials on glycerine: methanol evaporation; biogas production (grass, cow manure, 0%/5%/10% glycerine) (Turkish student from TU/e did preparations) (Diligent Tanzania has 400 m^3/ton cake digestion); soap production.

Short term actions:

- Building extra oil dryer;
- Building WVO solar preheating system;
- Building counterflow methanol condenser;
- Extra sedimentation and storage tanks;
- Interactive workshop on biodiesel production;
- Conversion of 4 diesel cars and an irrigation pump to PPO.

Dehusking of seeds is done by Titus/Gota Verde. Seed price $ 0,20/kg. Built after Fulbellyproject, two concrete moulds. Conical to make the gap adjustable. People are trained to build these themselves.

Fuel quality tested (test of PPO + biodiesel = $ 500 in Costa Rica). All parameters look good but many are ‘not detectable’. Probably the standard used is not really suited for biofuels.

Final production targeted 1000 tons per year, 3000 liter per day.

Termites and grass hoppers can very well eat jatropha. Probably they start with the leaves and then the roots. Niels shows pictures of completely destroyed jatropha plants from Mali.