Mission report
for 2nd mission to Guinea Bissau February 27th – March 10th 2014
a Consultancy carried out
for

ADPP, Guinea Bissau

Project tittle
"Renewable Energy for Local Development Bissorã Sector, Oio Region, Guinea Bissau"

Supported by the
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Appendix A: Daily notes and observations for NA´s Mission to Guinea Bissau for ADPP. From 27/2 to 10/3 2014

Appendix B: Email communication 26. may 2014 reporting conclusion from analysis of Jatropha oil, seeds and press cake.

Appendix C: Extract from 1st mission report chapter 3, regarding fuel quality.

2 Introduction

2.1 Project background

The activities in this report relates to the Action:

"Renewable Energy for Local Development, Bissorã Sector, Oio Region, Guinea Bissau", a project of 48 months duration – November 2011 to October 2015 – agreed in a contract between Fundacion Pueblo para Pueblo Spain and the European Union in contract number: FED / 2011/ 232-430, and with ADPP Guinea Bissau as implementing local organisation.

The Action has as its overall objective:

"Improve the living standards and local economic conditions in rural, low-income areas of Guinea-Bissau"

The Action has as it specific objectives:

Introduce and establish renewable energy systems for local development in Bissorã Sector, Oio Region in Guinea-Bissau. O1: Increase in solar and sustainable bio-fuel energy supply in rural areas.. O2: Increased human capacities to encourage renewable energy uptake in rural areas, wherever cost-effective. O3: Reduce environmental impact by promoting sustainable sources of energy.

The target groups are:

First level: 24 extension workers, 4 technical extension workers.

Second level: 14.274 community members of 24 communities in Bissorã Sector including 2.600 poor rural smallholder households.

2.2 The specific tasks for DAJOLKA/Niels Ansø on this 2nd mission:

- Follow up on issues related to 1st mission in august 2013, e.g.
  - problem reported with 1 genset in the field
  - problem operating 2 electrical machines with 1 genset.
- Operate the oil expeller which has been purchased from Senegal
- Preparing and handling Jatropha seeds for oil extraction
- Design and build filtration system for Jatropha oil for fuel
- Testing oil quality in the field

  All activities above to be carried out as an integrated part of the training.

2.3 DAJOLKA´s background

DAJOLKA is a Social Enterprise, established in Denmark in 1997, by Niels Ansø. (B.sc.Mec). Until 2005 DAJOLKA carried out non-profit activities parallel to Niels Ansø´s job as project engineer at the Danish NGO, Nordic Folkecenter for Renewable Energy, where he has worked with Pure Plant Oil (PPO) technology since January 1999. Since 2005 DAJOLKA has turned its activities to be profit oriented and Niels Ansø working full time at DAJOLKA within Renewable Energy Technologies.

2.4 Training program as suggested by ADPP

A PROPOSAL PLAN FOR THE SECOND MISSION VISIT OF NIELS ANSOE IN GUINEABISSAU			
DAY /DATE	ACTIVITY	PEOPLE INVOLVED	LOCATION
DAY 1 - 28/2/2014	Welcome to Bissora and Initial of the training by explanations of the experience by the participants from the first training	Fernando ,Petros+Tembo, Ramiano Jean ,Malam and the training Team	Vocational school and later a short visit to Watine CPC
DAY 2 - 1/03/2014	Training on how to operate the Presser.Revision training of the configuration of the Genset that it works with Two Machines at once, Preparations of the seeds to be pressed on the following day.	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa Balde, Malam Bide Sanha, Julio viera	Watine
DAY3 - 02/03/2014	Pressing the Jatropha seeds for oil and start the oil quality test and continue to Prepare the seeds for the following days.	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa Balde, Malam Bide Sanha, Julio viera	Watine
DAY 4 - 03/03/2014	Pressing the Jatropha seeds for oil and start the oil quality test and continue to Prepare the seeds for the following days.	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa Balde, Malam Bide Sanha, Julio viera	Watine
DAY 5- 04/03/2014	Organizing the oil storage system of the oil	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa Balde, Malam Bide Sanha, Julio viera	Watine
DAY 6 - 05/03/2014	Organizing the oil storage system of the oil	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa	Watine
DAY 7 - 06/03/2014	Oil Quality test and use in the generators	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa	Watine
DAY 8 - 07 /03/2014	Oil Quality test and use in the generators	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa	Watine
DAY 9 - 08 /03/2014	Revision of the traing for the previous days, thus oil test, storing and Filtration and Visiting CPC for Quere and Unfarim para ultim	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa Balde, Malam Bide Sanha, Julio viera	Watine, Quere, Umfarim
DAY 8 - 09 /03/2016	Conclusion of the training in Bissora, Travellling to Bissau and presentation of the Draft Report	Petros+Tembo and the training Team , Olavio, Ramiano, Antonio Batista, Eloy, Domingos, Dalanda, Yanaba, Mussa	Bissau

2.5 Introduction to PPO fuel quality

Since the fuel quality is of main importance for successfully operating of converted diesel engines on pure vegetable oil, the topic is briefly discussed here:

It is generally accepted that the German norm for rape seed oil as engine fuel, DIN51605, should apply to pure vegetable oil used as fuel in converted diesel engines. The norm specifies 8 natural parameters, which are more or less specified by nature, and 7 variable parameters, which are influences by harvest, handling and storing of the oil seeds, and by the process, handling and storing of the oil. For other vegetable oils than rape seed oil, the DIN51605 can be used as general reference, but each crop might have different natural and variable parameter relevant to PPO as a fuel.

The purpose of the quality standard is to ensure that the vegetable oil do not contain components and impurities which will weakening its own storing stability, and to limit the level of “strangers” in the fuel, which can negative impact on the combustion efficiency and leading to increased emission level and deposits in the engine, as well as avoid properties which can damage the injection system.

The norm has been updated several times – the latest version came into force from January 1st 2012, taking into account the newest European emissions norms, and the fact that most new passenger diesel cars on the European market are equipped with particulate filters, which make the engines very sensitive to contents of ash components like Phosphor(P), Calcium(Ca) and Magnesium(Mg) in the fuel. As a consequence of the latest update, rape seed oil produced by cold pressing and filtering alone, can no longer meet the limits for these parameters – its necessary to reduce the level of P, Ca and Mg by additional semi refining. But for engines without particulate filter, which in Europe are most engines produced before around 2005, and most engines in rural areas in developing countries, the previous version of DIN 51605, valid until 31/12 2011, can be used. This quality can normally be achieved just by careful cold pressing and filtering.

DIN V 51605(2011) – Quality Standard for Rape Seed Oil as engine fuel

The limits specified in DIN V 51605 (2011)[3)] is displayed in the table below. As indicated this is the version of the standard which was valid until December 31st 2011. These are limit are relevant to most engines found in developing countries.

Parameter	Limit	Unit
Characteristic/natural properties [1)]		
Density at 15 °C	900 - 930	kg/m³
Flashpoint Pensky- Martens	min. 101	°C
Kinematic viscosity at 40 °C	max. 36,0	mm²/s
Calorific value (incl. H2O –Correction)	min. 36.000	kJ/kg
Cetane number	min. 40	-
Carbon residue CCR (from Original)	max. 0,40	% (m/m)
Iodine number	95 - 125	g Jod/100 g
Sulfur content	max. 10	mg/kg
Variable properties [2)]		
Total contamination	max. 24	mg/kg
Acid number	max. 2,0	mg KOH/g
Oxidation stability	min. 6,0	h
Phosphorus content	max. 12	mg/kg
Earth alkali content (Ca + Mg)	max. 20	mg/kg
Ash content	max. 0,01	% (m/m)
Water content	max. 0,075	% (m/m)

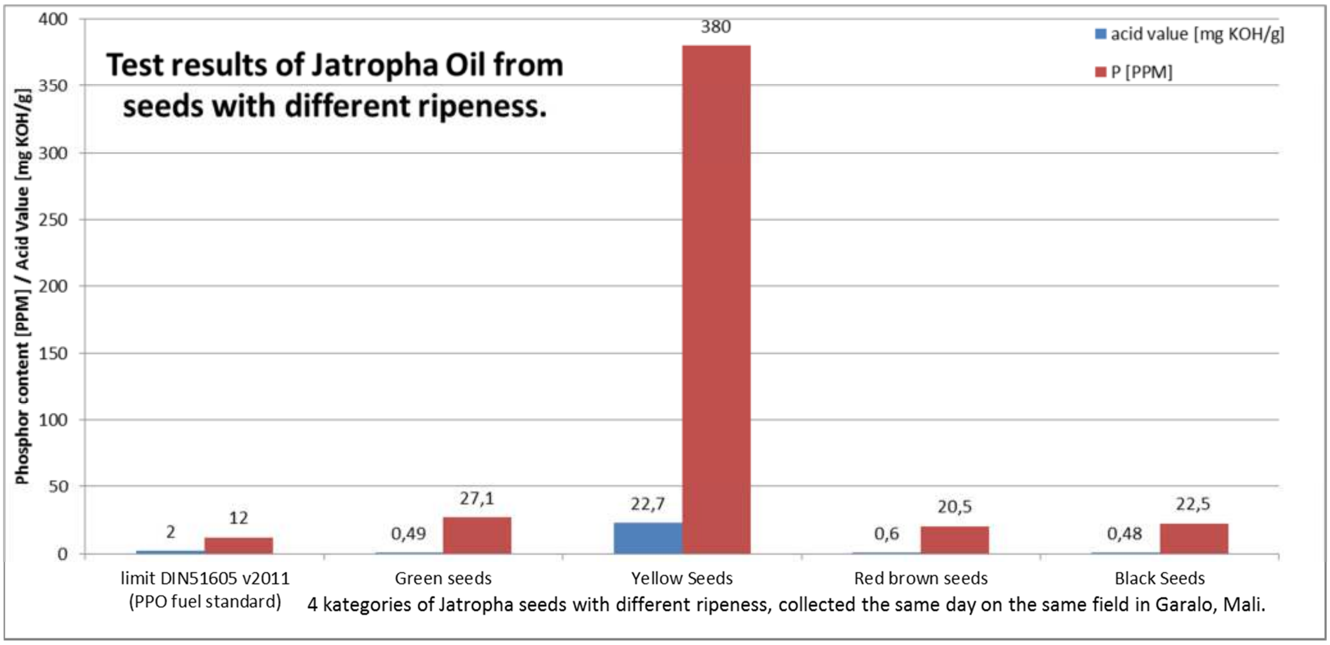
1) The natural properties which are independent from the process, handling and storing.
2) The variable properties which are influenced by the process, handling and storing
3) A new version of DIN 51605, with reduced limits for ash building components, were introduced by January 1st 2012,

especially to meet requirements for the newest type diesel engines with particulate filter installed. The limits in the table above are from the DIN norm before January 1st, and are suitable for diesel engines without particulate filter.

The different PPO fuel quality parameters are explained in details in Appendix C.

We have seen a wide variety of test results of Jatropha oil quality, and we have tried to draw parallels from our experiences with rape seed oil to Jatropha oil. It seems that high acidity, which often is combined with high levels of phosphor, Ca and Mg, is the main challenge with Jatropha oil. From rape seed we know that there are clear relation between seed quality, including seed ripeness, and the quality of the expelled PPO. We have previously made test of Jatropha seeds of different ripeness, but further experiments has to be done to toughly understand the relations between seed quality and PPO quality.

4 different Jatropha seeds with different ripeness collected at 1 field in Mali.



3 Preparations

From Denmark we had prepared the follow materials to bring to Guinea Bissau for this mission

- Small laboratory test kit for analyzing PPO in the field
- Pumps, filters, hoses and pipe fittings, needed to build a filtration system.
- Fuel filters for replacement of broken filter from previous mission(workshop).

4 Training Sessions

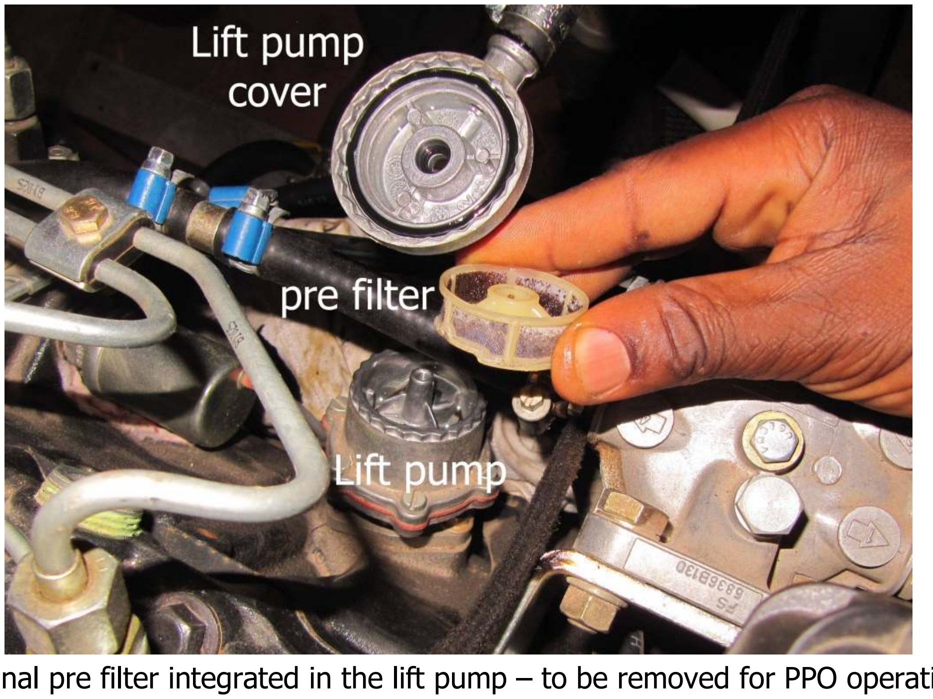
Several topics had to be addressed during the training workshop. Since the high number of participant, it was possible to separate the participants into groups, working parallel on several topic at the same time.

At the end of each day there was held an evaluation, where all participants should evaluate their own performance as well as they could comment on the performance of the other participants. We found that evaluation system very useful and constructive for all participants and the trainers, which we believe is unique for ADPP training activities, and which other projects should learn from.

4.1 Follow up on issues related to 1st mission in august 2013

4.1.1 Training in engine conversion

After the previous workshop where the gensets were installed and the engines converted to PPO, I have realized the Perkins 403D engines has an integrated pre filter in the fuel lift pump. The pre filter is to protect the lift pump from malfunction, because larger impurities can disturb the function of the 2 integrated non-return valves. But this original pre filter is very small and mesh size very fine, so it might work as a bottle neck in the fuel system when operating with PPO which has much higher viscosity than diesel. Therefor it is better to remove this original filter from the lift pump, and replace it by a larger external pre-filter on the fuel line before the lift pump. The larger external filter was installed already at the first training workshop in August, so at this workshop the only thing to do was to remove the small original filter from the lift pump. This was done with the gensets at the main center where the training workshop were held. The filters on the other gensets installed in the villages would be removed later on.

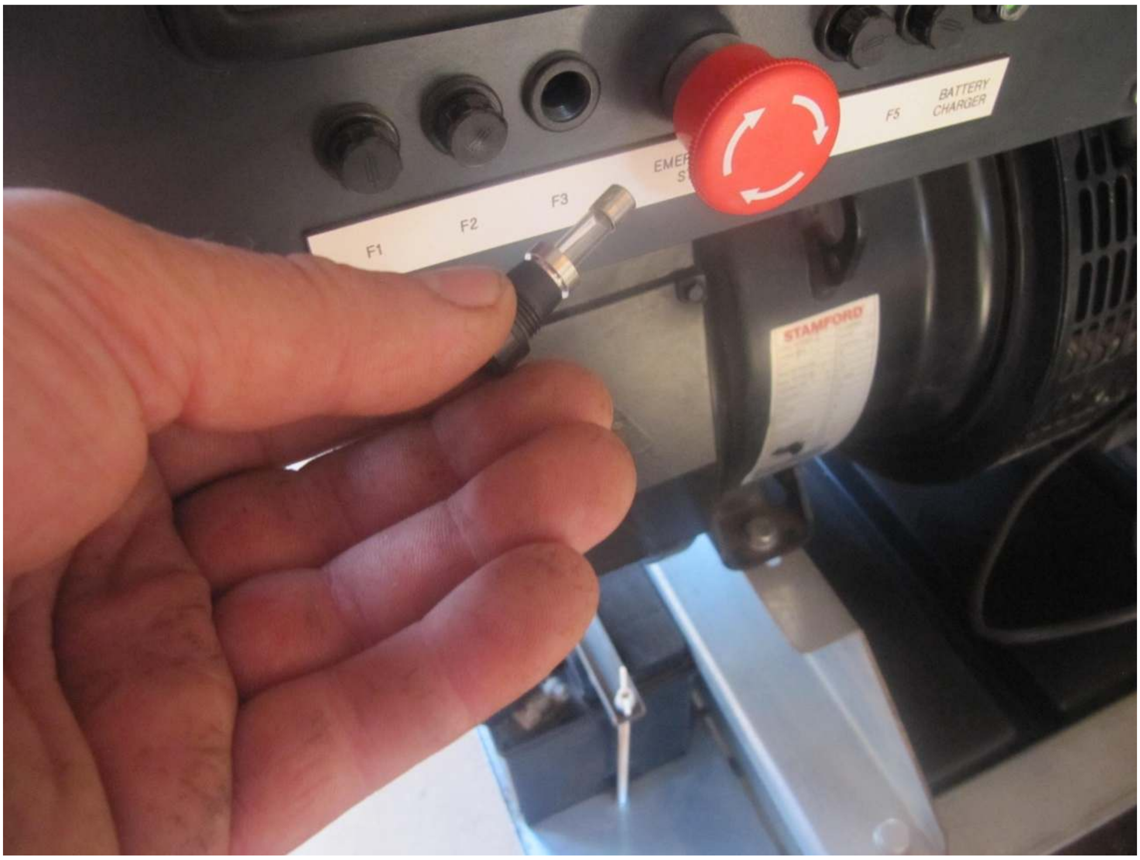


Original pre filter integrated in the lift pump – to be removed for PPO operation.

4.1.2 Problem reported with 1 genset in the field

In the afternoon on 6th training day (march 6th), we traveled by car to the village where the genset refused to operate indicating an error with low voltage on 1 of the 3 phases.

Initially the wiring system of the genset and the DSE control system were studied, to figure out where a possible mistake could be. It led to check the fuses on the front panel of the DSE control system, and the error was found to be caused by a loose fuse. After tightening the fuse, the genset worked normal again without any errors.



Found that the error was coursed by one of fuses which had become loose.

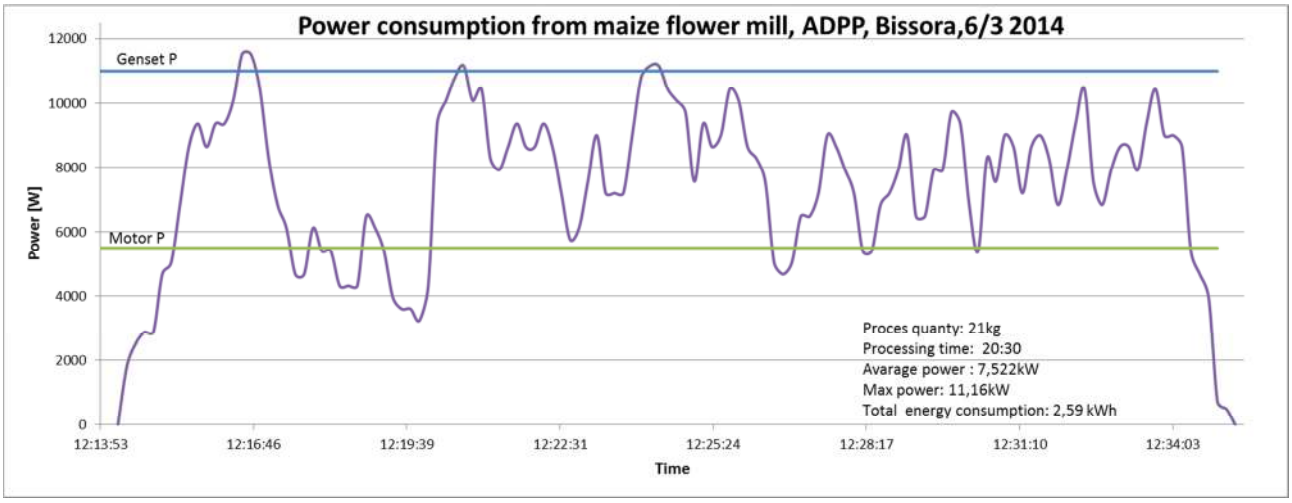
The next day we provoked the same error to come at the genset in the main center, and the participants were asked to trouble shoot and identify the problem.

4.1.3 Problem operating 2 electrical machines with 1 genset.

One challenge to operated 3 phase electrical motors on standalone grids supplied with power from a genset, is that the electrical motor is drawing 3 times nominal current just at the start up. This might "stall" the grid, or the genset will cut off and stop because of overload. The DSE control system for the gensets had already been adjusted to allow short overload allowing 3-phase motors to start up. But still there were problems with the capacity of the grid when needing to run 2 electrical at the time.

Therefor we measured the actual consumed power on the different process machine, using the KAMSTRUP 3-phase electrical meter together with the USB data logger, which I brought for the 1st mission in August 2013.

Left photo: The meter with cables, socket and plug, and data logger.
Middle photo: The meter installed on the power supply for the maize mill.
Right photo: Detail of the meter and USB data logger.



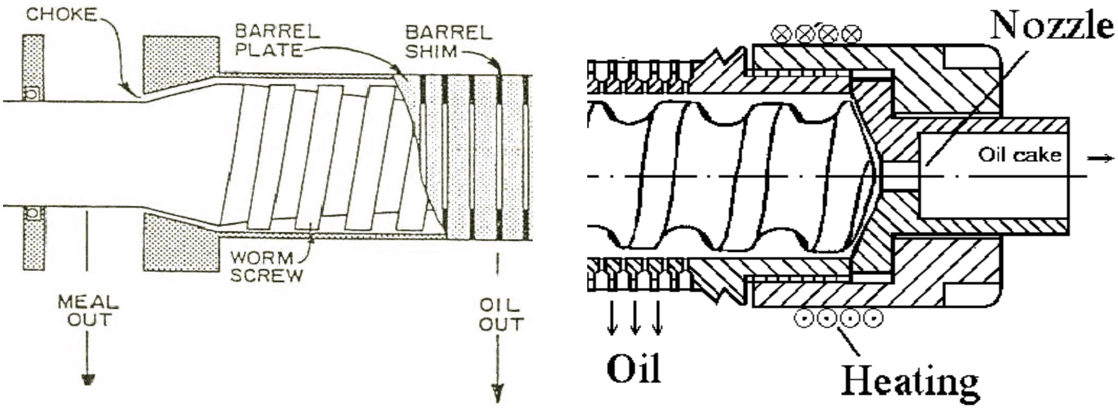
Here are example of the measured power consumption on the maize mill with the sieve with smallest holes for the finest flour. The power consumption was up to twice as high as the much 5,5kW nominal power of the motor, which is the same as the full capacity of the genset (~11kW). The lesson learned was that the load on the motor is strongly depending on the way it is operated, and that the operator has to learn and care about not to force the maize mill too much, over loading the system.

The issue operating 2 electrical motors at the same time was tested further. The conclusion was that it is very challenging to start the second motor without stalling the electrical grid. The conclusion was the second motor has to be started using a soft starter device limiting the current drawn by the motor at start up.

After the mission we found a suitable soft starter device for 3 phase motors, which limits the starting current on all 3 phases during startup of the motor..

4.2 Operate the oil expeller

The oil expeller had been purchased from Senegal, and was supposed to be working with Jatropha seeds. It was a "strainer" type oil expeller, which has a relatively long screw which rotates inside a press case house made from barrels. At the end of the screw is a conical gab for the press cake exit. The gab can be adjusted for changing the counter pressure inside the oil expeller. The oil is drained out though very small gabs between the barrels.



Oil and press cake outlets from "strainer"(left) and "nozzle"(right) type oil expellers.

Initially we had to figure out how to assemble and adjust the expeller correctly – no manual or documentation was present. We made many test runs, and changed the adjustment of the expeller.

But it was very difficult to make it run smooth with the Jatropha seeds. And we measured that the temperature in the oil from the expeller increased up to 145°C, which is far too high to make good quality oil.

The high temperature indicated that something was wrong – it could be the settings, the design, the seed quality, or a combination of all these. From previous projects had contact to the manufacturer of many oil expellers found on the African market, and he confirmed that this expeller originally have been manufactured by his company. Finally we got the manual for our expeller from this manufacturer, and we could conclude that this expeller had been designed to work will small seeds like rape/Colza, linseed, etc. and to operate at high temperature (hot pressing). It has not been designed to work with large seeds like Jatropha.

Therefor we had to conclude that this expeller could not be used for the project – at least not as it was. It might be possible to get better result by reducing the screw speed by increasing the gear ratio between the pulleys, and/or to change the electrical motor for an 8 pole version which runs half the speed (750RPM) compared to the standard motor we had.

After the mission we also proposed the possibility to test a Danish oil expeller which we had tested with Jatropha seeds before, and we proposed a Chinese oil expeller, suitable for Jatropha seeds pressing a low temperature.

4.3 Preparing and handling Jatropha seeds for oil extraction

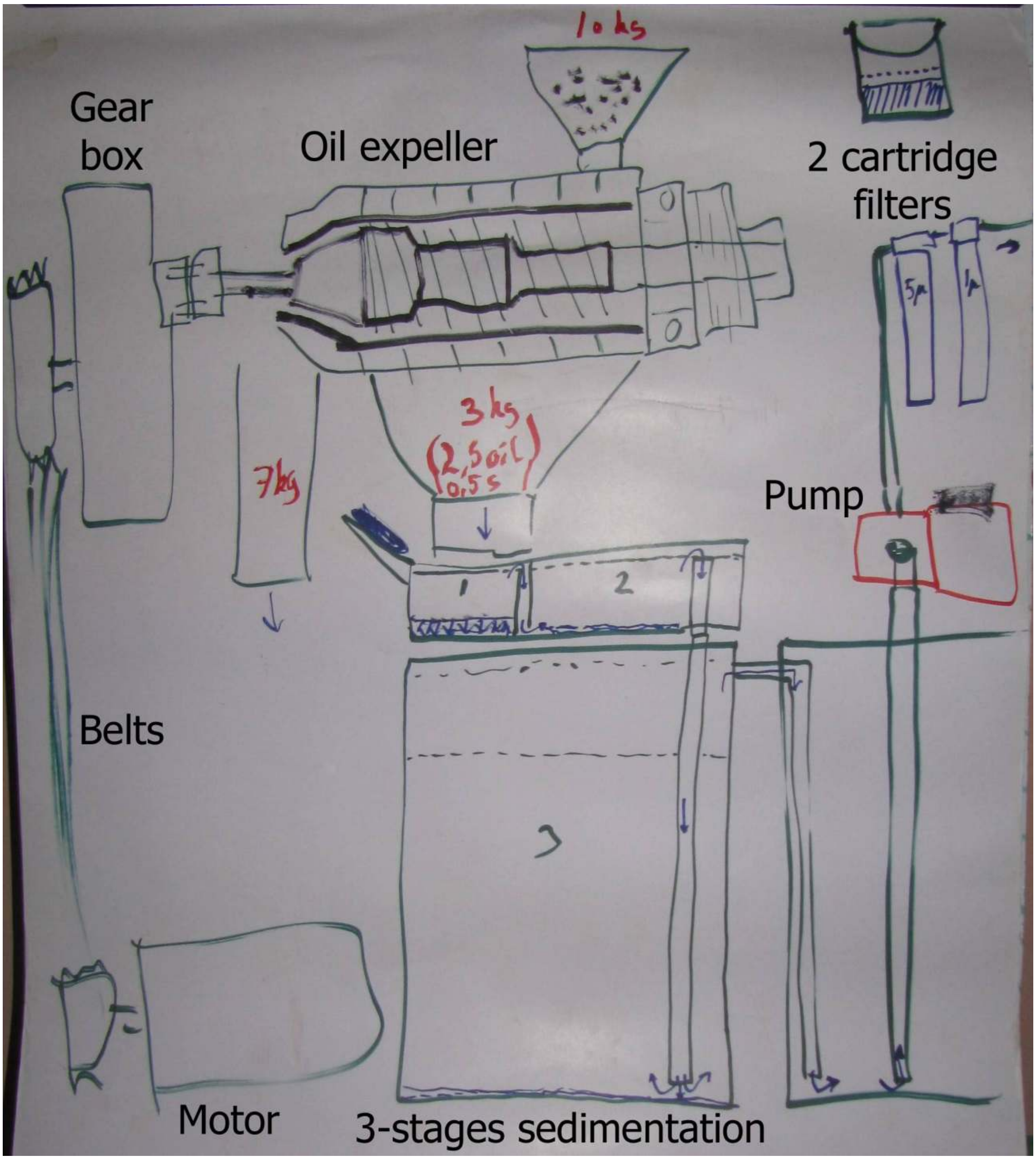
In order to get the highest oil yield, best oil quality and to minimize wear on the oil expeller, the seeds should be cleaned for dust and stones and other impurities. All broken seeds have to be removed as well, because the oil from a broken seeds has been oxidized and therefor will have high acidity (% FFA), which will contaminate the good oil from good seeds. It is also important that the seeds have the right ripeness and humidity (6-8% water). For storing the seeds it is also important that the humidity is low enough for stable storing conditions without composting, which develops heat and mold in the seed pile, which leads to very bad oil quality with high acidity later on at the pressing.

Jatropha seeds are being cleaned from dust and other impurities, and broken seeds removed.

Broken seeds(left) and empty shell(up) are removed to press only good seeds(right).

4.4 Design and build filtration system for Jatropha oil for fuel

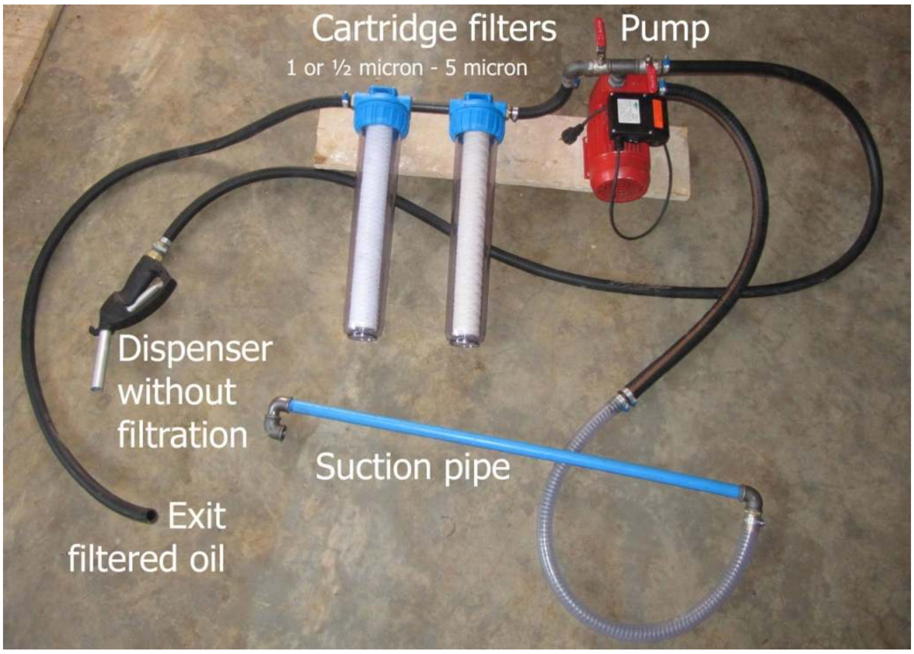
The crude Jatropha oil typically contains up to 20% dirt just after the pressing. The easiest way to remove most of the dirt is by sedimentation in a tank or a barrel, where the oil can rest for. e.g. 1 week. Sedimentation systems are suitable for small installations like for this project. For larger capacity installations, sedimentation is not suitable due to the need for very large sedimentation tanks. For larger project is more feasible to use special chamber filters with large capacity for the 1st stage rough filtration. For both types of rough filtration, it is necessary to pass the oil though a fine filtration system after the rough filtration – typically in 2 stages – 5 micron filter followed by 1 or ½ micron.



Drawing of the oil pressing and filtration systems – made on the paper board for the training.

The principle of the sedimentation system is to lead the crude dirty oil directly to the bottom of the sedimentation tank. Each stage of the sedimentation system has an overflow to the bottom of the next tank. Dirt is accumulating at the bottom of each sedimentation tank, and clean oil ends up in the last tank. The retention time in an efficient working sedimentation system is approximately minimum 1 week.

3 stage sedimentation system and buffer tank(left).
Detail of 1st & 2nd stage sedimentation system(right)



The electrical pump and filter cartridges ready. The blue pipe is for suction of PPO from the sedimentation- or storage tanks. It can be pumped though the filter for safety fine filtrate 5 and 1 micron respectively, or the PPO can by-pass the filters and be delivered through dispenser, to fill canisters with clean oil.

4.5 Testing oil quality in the field

To get and fast impression about the oil quality it is very useful to be able to make some simple field tests of the quality. The acidity (% Free Fatty Acids, FFA) can be measured by titration, and is a very important parameter, not only because high acidity can damage the injection system rapidly, but also because high acidity is often accompanied by high values of Phosphor, Calcium and Magnesium, which are dangerous for the engine and which leads to high emissions levels. The field tests should always be compared to real laboratory tests for checking.

For the titration I had brought pipettes, ingredients etc. from Denmark, except for the isopropyl alcohol, which is not allowed to carry on air flights.

Ingredients for titration to determine the FFA content.
From left: NaOH solution, Phenol red powder in alcohol and alcohol.

Titration results calculator				
Use green cells for input for the calculation.				
density SVO	0,92	kg/liter		
NaOH titration solution concentration	1,00	g/liter	0,10%	
sample ID	titration solution [ml]	mg NaOH/g	FFA%	mg KOH/g
ADPP Bissora, SVO sample 5	5,1	5,54	1,95	3,89
ADPP Bissora, SVO sample 5	4,5	4,89	1,72	3,43
		0,00	0,00	0,00
		0,00	0,00	0,00
		0,00	0,00	0,00
average	4,8	5,22	1,83	3,66
Offial limit acid value according to DIN51605				2,0
acceptable level up to				3,0-3,5
not acceptable				> 4,0

The table shows a calculation tool we have made in Excel to calculate results from the titration

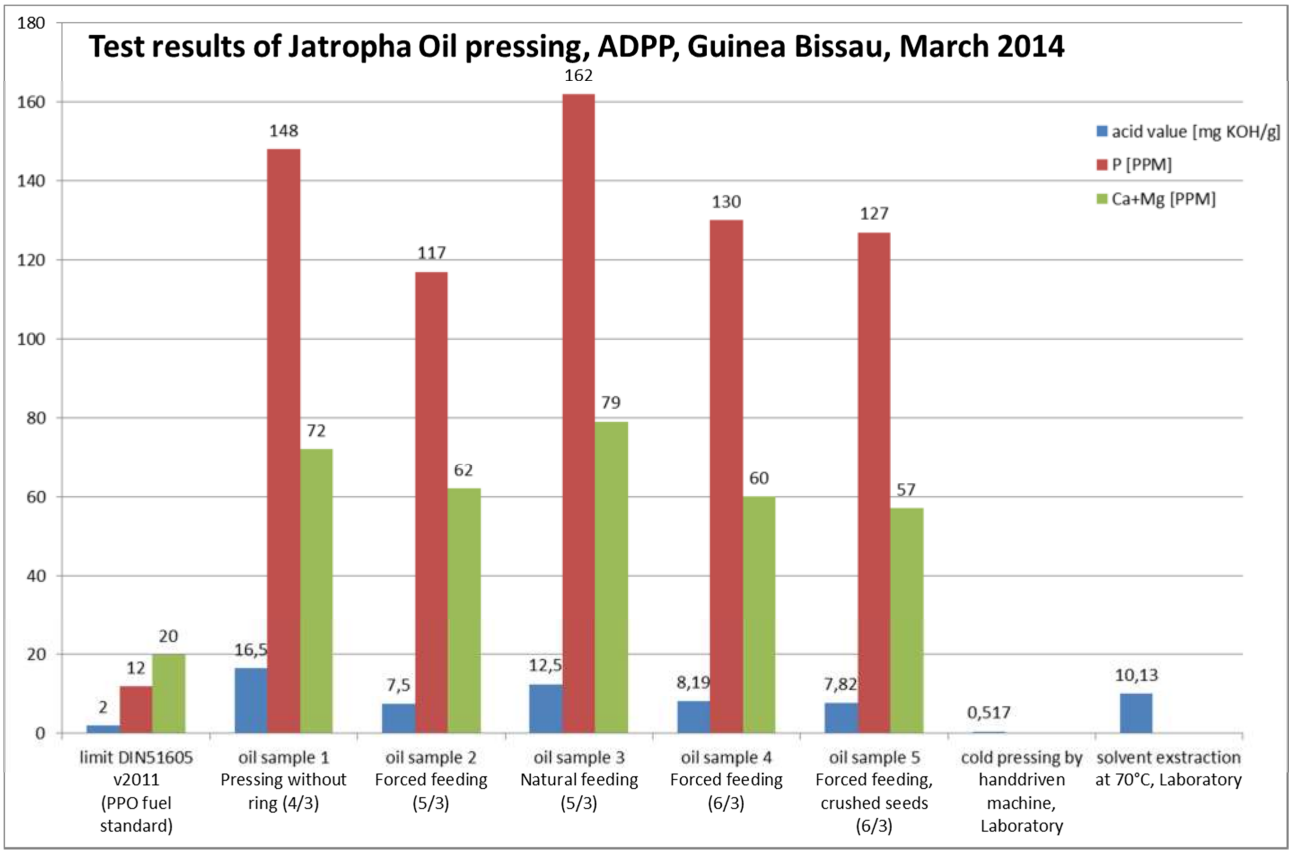
4.6 Testing oil quality in laboratory

Samples of oil, press cakes and seeds were brought back to Denmark and sent to laboratory in Germany for analyzing. The purpose was to compare the field test with the results from the laboratory, and in addition to make further test of the oil, seeds and press cake.

	sample and test methode	acid value [mg KOH/g]	P [PPM]	Ca+Mg [PPM]
	limit DIN51605 v2011 (PPO fuel standard)	2	12	20
Oil exstracted in the field in Guinea Bissau	oil sample 1 Pressing without ring (4/3)	16,5	148	72
	oil sample 2 Forced feeding (5/3)	7,5	117	62
	oil sample 3 Natural feeding (5/3)	12,5	162	79
	oil sample 4 Forced feeding (6/3)	8,19	130	60
	oil sample 5 Forced feeding, crushed seeds (6/3)	7,82	127	57
Oil exstracted Laboratory Germany	cold pressing by handdriven machine,	0,517		
	solvent exstraction at 70°C, Laboratory	10,13		

Results from analysis at the laboratory in Germany.
Oil samples no´s 1-5 were pressed in Guinea Bissau. For checking seed quality, a seed sample was sent to the laboratory, where they pressed to oil out at low temperature by a hand driven oil expeller. An additional test was made in the laboratory extracting the oil by solvent and 70°C, to simulate pressing oil at very high temperature like happened in Guinea Bissau.

The results from the laboratory shows that all oil samples from Guinea Bissau had too high acid value, but the oil sample pressed a low temperature in the laboratory had very low acid value, indicating that seed quality/ripeness was OK. The additional test with solvent extraction confirmed that rough conditions at high temperature during the oil pressing lead to high acid values. From several previous tests we know that with high acid values are accompanied by high values of Phosphor, Calcium and Magnesium.



Test results from the laboratory of oil quality, showing the all oil samples from Guinea Bissau had far too high values of acid (FFA), Phosphor, Calcium and Magnesium.

The conclusion regarding oil quality and oil pressing is that the oil expeller purchased from Senegal cannot be used to produce fuel quality Jatropha oil, but also that the oil in the seeds seems to be OK. There for the oil expeller should be modified or changed by another type expeller. Further attention should be paid also to the seed quality including time of harvesting in relation to the seed ripeness.

For further details please look Appendix B:
Email communication 26. May 2014 reporting conclusion from analysis of Jatropha oil, seeds and press cake.

5 Follow-up

The following issues have to be followed up.

- install soft starter device to reduce stating current on 3-phase electrical motors allowing larger motors to run 2 at the same time
- modify pulleys on the existing oil expeller to reduce rotation speed of the screw to reduce heat developed by friction
- buy Danish or Chinese oil expeller more suitable for Jatropha seeds.
- study and pay attention to the seed ripeness at harvest, and the seed condition during storing.

6 Conclusion

All technical tasks were completed within the planned time schedule. Problems were solved or solutions suggested to be implemented later. That includes

- follow up on the genset conversion, removing original pre filters.
- solving problem with 1 genset which refused to operate due to error in the control system
- detecting problem that 2 electrical motor could not run at the same time
- install and run the oil expeller from Senegal.
- built oil filtration system including a sedimentation system and a pump filter system
- clean the seeds for better oil quality and less wear on the oil expeller
- test the oil quality in the field

The training workshop had been planned very well by ADPP.

Dronninglund, Denmark,

march 2015

Niels Ansø

Thursday 27/2:

Depart from home 9:00 to take plane Aalborg – Copenhagen, then Copenhagen-Lisboa-Dakar.

Friday 28/2:

Arrived Dakar at 01:00. Stayed in airport and flew to Bissau 10:40. Plane couldn’t land and returned to Dakar. Stayed in airport until 18:30, and then was transferred to hotel.

Saturday 1/3:

Stayed at hotel in Dakar until 18:00, then went to airport and flew to Bissau via Conakry.
Arrived Bissau around 23:00.
Went from Bissau to Bissora - arrived at 02:00.

Sunday 2/3:

Started work at 8:00. Met at the school and then moved to the main agricultural center.

Plan from the morning:
It was agreed immediately to start working on the PPO production system, while there are many topics and challenges to work with, and because the PPO production takes time, especially because of the sedimentation cleaning system, which is planned to be the first part of the filtration system.

Initially the equipment’s brought by NA was unpacked, and displayed for the participants.

2 units Sealand(Italy) Impeller pumps, 230V, 590W(0,8hp)
max. 40-50liter/min, max pressure 2,5bars (25m), Self priming.

The impeller pumps are often used for domestic water pumping and for diesel filling stations in agricultural sector. The pump design is also suitable for PPO, but the startup can be challenging for some pump motors when the PPO is cold and high viscous. The pump is also suitable for filtration, while it is self-limiting the pressure at about max 2,5bar.

2 units 20 inches cartridge filter houses, with mounting brackets and wrench.
4 cotton string filter cartridges – 2x½ micron and 2x5 micron.

Fuel filter to replace original filter on the genset, which was broking during august workshop.

Fuel hoses to connect pumps and filters

Photo dispenser for filling station

Pipe fittings to connect filters and pump.

Training session in function of the oil expeller and expected output from it, which are 3 fractions: Press cake, and a mixture of PPO and soot's (dirt).

Talk about different filtration systems, depending of capacity of installation.

Conclusion was that the project wants to produce 400 liters per week, and for that capacity sedimentation system combined with a fine filtration system is more suitable.

Talk about quality of the seed and oil, and compare with quality of food production.

First enemy regarding fuel quality is the oxygen in the air, which decompose the oil when broken seeds and oil is exposed to atmospheric air (like an apple getting brown and spoiled very fast if you drop it on the floor, damaging the surface/skin)

Design and produce the sedimentation system.

Checking the oil expeller and agree how to install it. We had to build a frame with supports to lift the expeller up from the ground in order to build an oil sedimentation system with natural flow by gravity.

Preparing steel parts for frame and legs to support the oil expeller.

Welding legs to the support frame

Explain the oil production system with oil expeller, sedimentation system and fine filtration system.

The oil expeller installed on legs, and preparing the 3-stage sedimentation system, using oil drums.

Monday 3/3:

Plan from morning:
Focus on Jatropha seed quality and starting up pressing oil, including make measurement on the output from the oil press at different adjustments, and note qualitative parameters. Take out ½ liter oil samples in empty and dried water bottles.

Speed of screw was measured to 136 rpm. That seems very high. It should be confirm with the manual, but the manual is still not there. When we know the correct speed of the screw, we can figure out if the motor and pulley are correct.

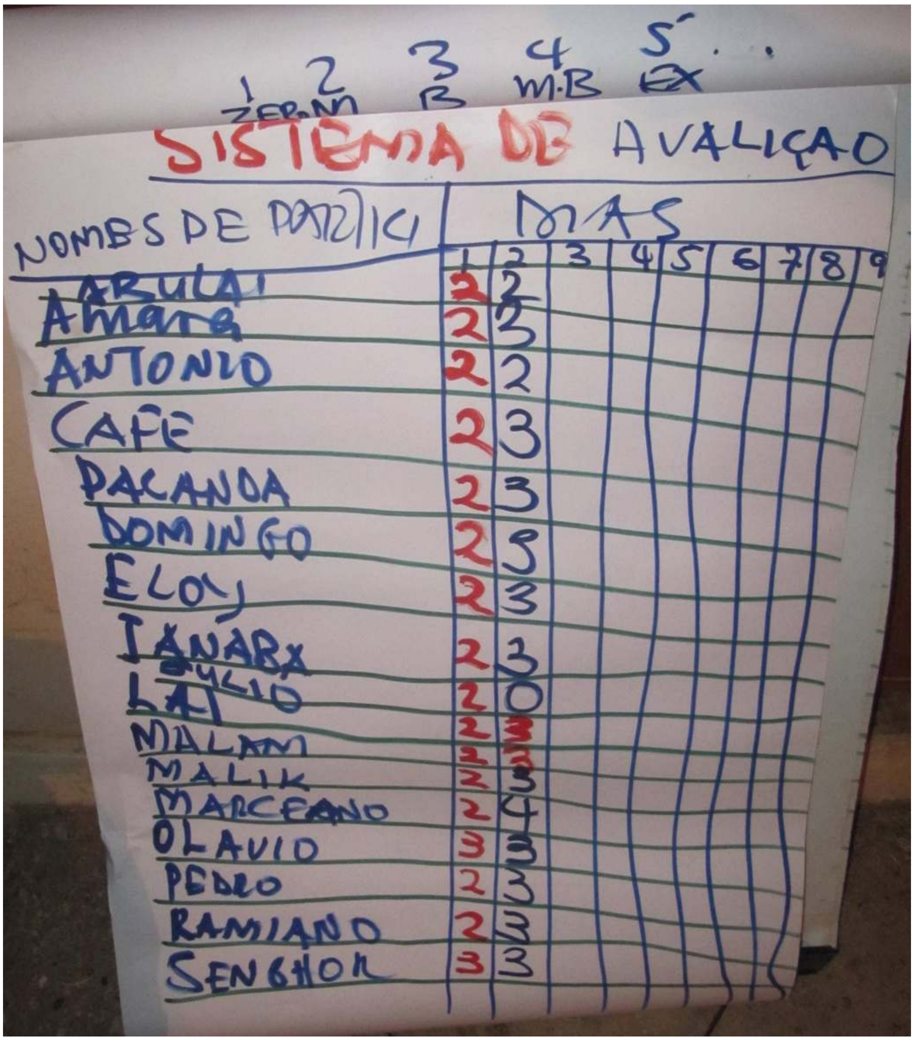
The supplier of oilpress said that the motor is 5,5 KVA (4,4kW) running 3000RPM.

When oil press was working we measured power consumption of 4-4,5A which corresponds 2,63-2,95kW, but sometimes the output increase dramatically and the motor consumes 8 A or 5,26Kw or 20% overload. At the low load the there was hardly any oil and press cake disposed from the expeller, but a lot of heat was generated inside. But when the load when up to the expeller suddenly would release a lot of very hot oil and press cake, and then again stop release oil after 30-60 seconds.

Jatropha seeds are being cleaned from dust and other impurities, and broken seeds removed.

Broken seeds(left) and empty shell(up) are removed to press only good seeds(right).

During test of the oil expeller the main bearing for the screw broke. I new bearing was found on the local market and changed.



Results of evaluation at the end of day 2

Tuesday 4/3:

Plan from morning:

Figure out more technical details about the oil expeller, and try to make it operate better.
Get the details from the supplier (present at the workshop)

Investigate exchange ratio on the revolutions from electric motor to the press screw.

exchange ratio 1:11.

Screw speed measured to 136 RMP.

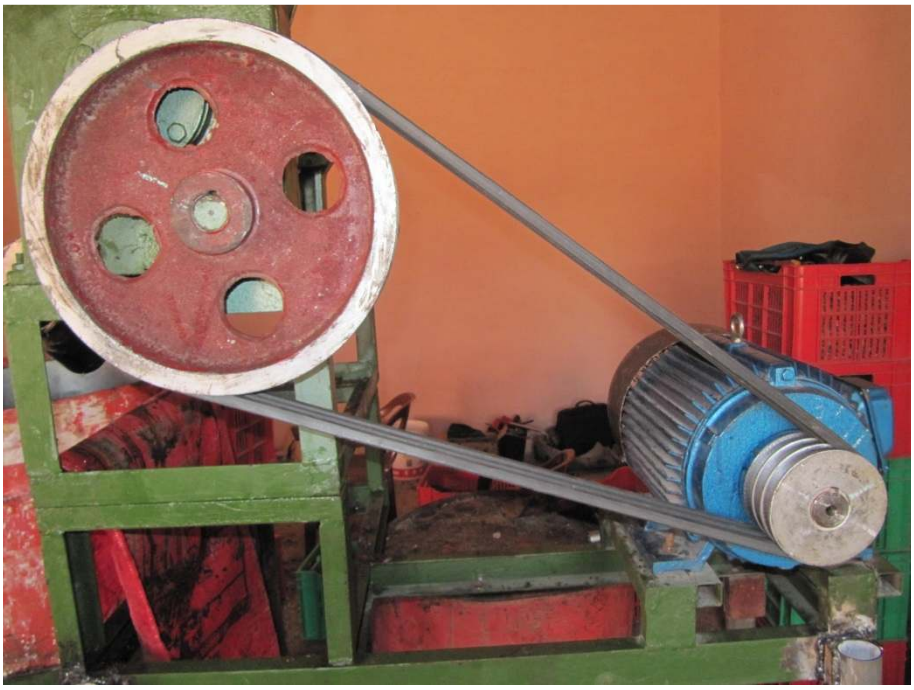
That means that it is a 4 pole motor with nominal speed 1500 RPM (136 x 11 = 1496).

Regarding the screw speed of 136 rpm I´m suspicious that it is too fast for this size of screw. The screw diameter is about Ø67mm, and usually smaller diameter screw should spin faster and larger screw should spin slower. We know from another screw press with Ø50mm screw that it is spinning only 70rpm. Therefor I believe that this screw should only spin around half of the speed which it is spinning now. Then it will generate much lower friction heat, and the throughput will be reduced. As the throughput we see now is very high at these moments when cake and oil suddenly start to pass the expeller. The theory could be that if the screw is spinning too fast, the cake don´t have enough time to release the oil and/or if the throughput is too high, it will maybe cool the press too much, and then et needs again some time to generate friction heat enough to start to release cake and oil.

Consideration regarding oil expeller screw speed adjustment:

We can half the revolutions using an 8 pole motor with nominal speed of 750 RPM, but nobody believe that we can get that in Bissau.

The other option is to change the size of the pulleys. The large pulley on the gearbox has diameter Ø337mm (mid of belt) and the small pulley on the motor Ø113mm. The gives an exchange ratio of 337/113 = 2,98. In order to half the speed we need to find smaller pulley for the motor and larger for the gearbox, so we get new exchange ratio of 5,96.



Pulleys in the motor and gearbox.

Test pressing was done over a longer period approximately 30-45minuttes. Since the yield from the press fluctuated a lot – mostly giving nearly nothing – its not relevant to use this measurement to calculate throughput. But the crude oil and press cake was collected and measured. There was 3,38kg oil and 8,44kg cake, totaling 11,82kg. It gives 28,6% crude oil and 71,4% press cake – close to the 30-70% ratio we were teaching 2 days before.

Rise husk was tested for cleaning the oil expeller for press cake before shutting down, and it seems to work fine. Then after stopping the oil expeller it should be reversed manually for emptying the press house as much as possible.

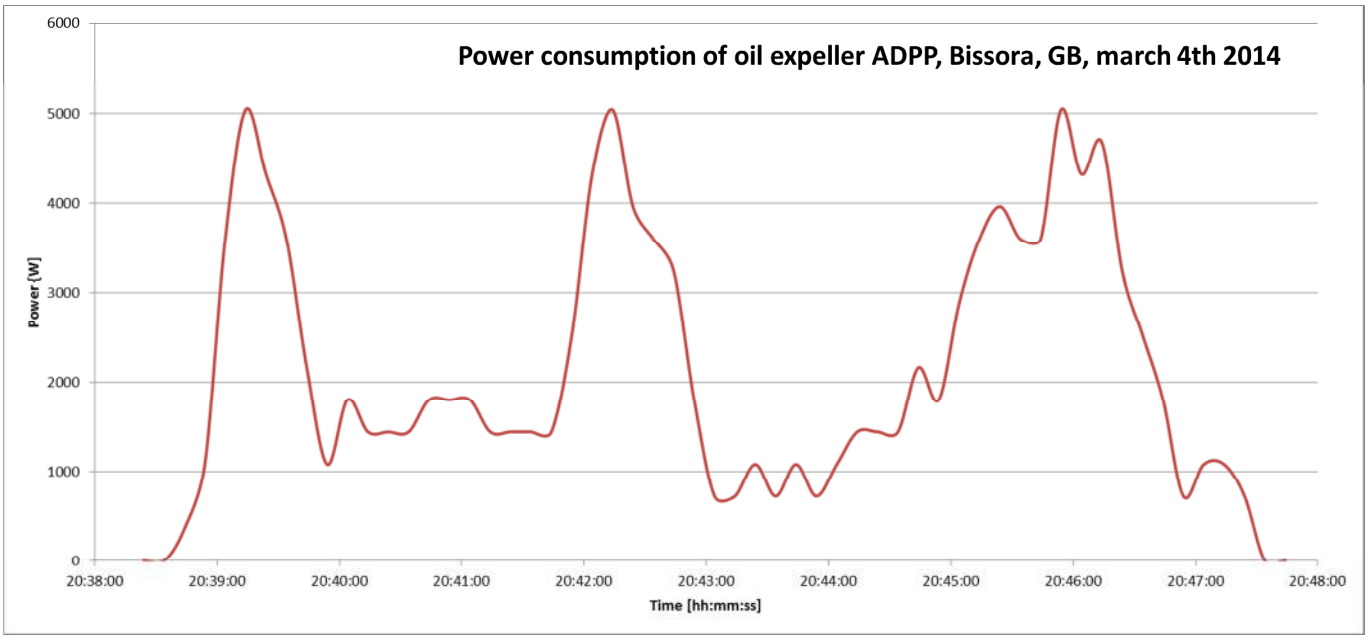
The Kamstrup electrical meter with data logger was installed on a small wooden plate and connection with 2 short 4x4mm2 cable with a male and female plug respectively, so that the meter can be moved around and measure power consumption from each individual processing machine. The first testing of the meter was done with the oil press.

Further test with the oil expeller. The person operating it on the photo was very quiet and modest, but he was the one who was present when a technician from Senegal has visiting the site some weeks before, so he was the one you observed what than technician had done and said.

Measuring temperature of the oil and press cake released from the oil expeller – here press cake temperature 104°C.

oil expeller working

Press cake



First test run of oil expeller with measurements of the power consumption. The stop-go-stop-go operation mode of the oil expeller is clearly recognized in the peaks in power consumption, which occurs each time the press cake and oil is released from the expeller.

Wednesday 5/3:

From the morning, after starting the activities at the main center, we decided to go the ADPP office at the school in Bissora, to have better internet communication facilities, in order to search technical informations about the oil expeller. Tembo found some useful technical informations on Alibaba, and I contacted the owner of the Double Elephant oil presses in China. He confirmed that the oil press is one of his products, and confirmed indirectly that the rotation speed of the screw was correct, and we could conclude not to work more on the idea to try to reduce the speed of the screw.

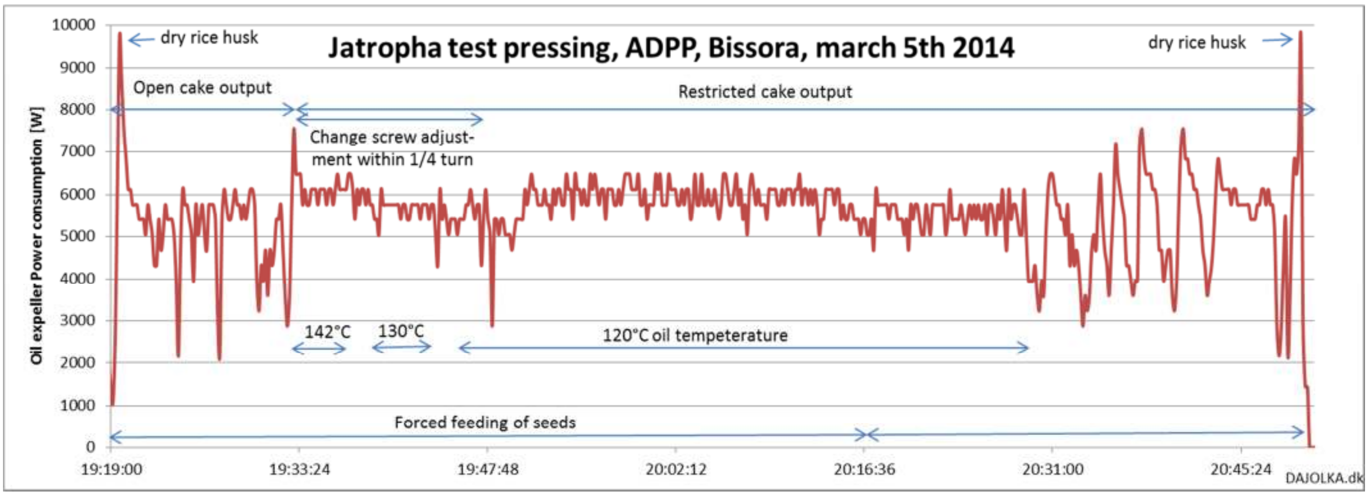
The manufacturer of the oil expeller recommended reducing size of the seeds to rice size.

He also confirmed that the conical ring to install at the end of the screw, is an important part of the oil expeller, and should not be removed such as recommended and done by the technician from the supplier Ecomar.

With these informations we went back to the main center and tried once more to operate the oil expeller. Before started the oil expeller was disassembled and cleaned.

The geometry around the end of the screw and the conical ring(restriction) on the press casing were investigated carefully in order to figure out at which position of the screw adjust the ring would start to make resistance to the press cake. It was concluded that this happens when the adjustment handle is 6 turns out (at 2 turns out the conical part of the screw is complete in contact with the conical ring, corresponding a press cake thickness of 0mm),

In order to be sure that the ring would not make any resistance for the press cake for starting up, the adjustment screw was turned 8 turns out, and the oil expeller was started.



Initially the oil expeller was fed by rice husk in order to heat up the press casing by friction. Then Jatropha seeds were fed and an oily press cake started to leave the expeller, but hardly any oil came from the oil drains. That period is indicated "open cake output" on the curve above. Them the adjustment screw was turned in – first one rotation and then another one – and the press cake suddenly changed character to be thicker dry flakes, and oil started to come from the oil drains. The temperature went up, and an oil temperature up to 142°C was measured, which is very high. The cake was very dry. Then the adjustment screw was turned a little out, and the oil temperature dropped to 130°C and the cake became less dry. The again the adjustment screw was turned a little out, and the oil temperature dropped to 120°C. The adjustment was left like that for the rest for the test run that day.

The Jatropha seeds were fed to the inlet funnel manually by small buckets, and during the first part of the test the seeds were partly forced down in the funnel with a piece of ¾" plastic pipe, because the seed tends to form "bridge" in the funnel, which stops the feeding. In this mode an throughput of 76kg seeds/h was measured, and an oil yield of 33,1% (including dirt). An representative oil sample was taken out directly from the oil drain, and marked no. 2.

After that, from approximately 20:16, the seeds were feed without forcing them into the funnel. A throughput of 68kg seed/h was measured, and the oil yield was measured to 31% (including dirt). Another oil sample was taking out and marked no. 3.

Initially the feeding of the seeds went well without forcing the seeds into the funnel, but after approximately 15 minutes fluctuations occurs in the throughput, oil and cake production, which is also recognized on the power consumption.

The test pressing was finalized by feeding rice husk for emptying the screw and press casing for oil cake, which tends to became very hard after cooling down and standing for the next day, and which makes it difficult or impossible to get the oil pressing started next time, without taking the screw out of the press casing for cleaning.

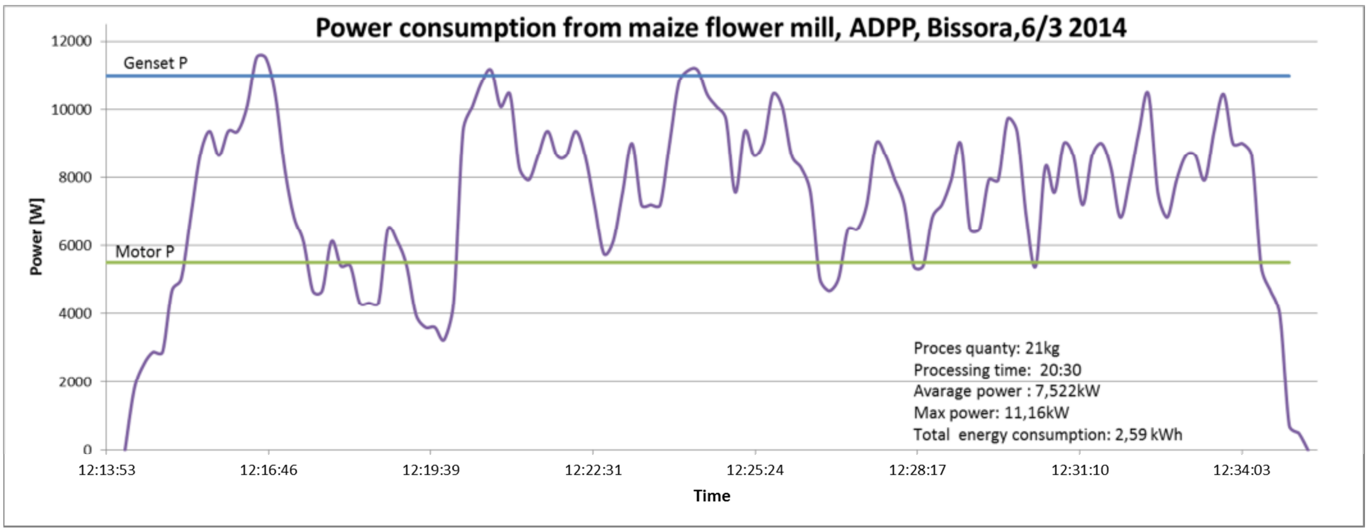
Initializing and ended the pressing feeding rice husk is something I learned from an Indian oil expeller manufacturer, and it seems to work fine, except that the rice husk is very dry. Therefor some rice husk was prepared by adding about 10% water.

The sedimentation system starts to fill up. Here to first 2 stages.

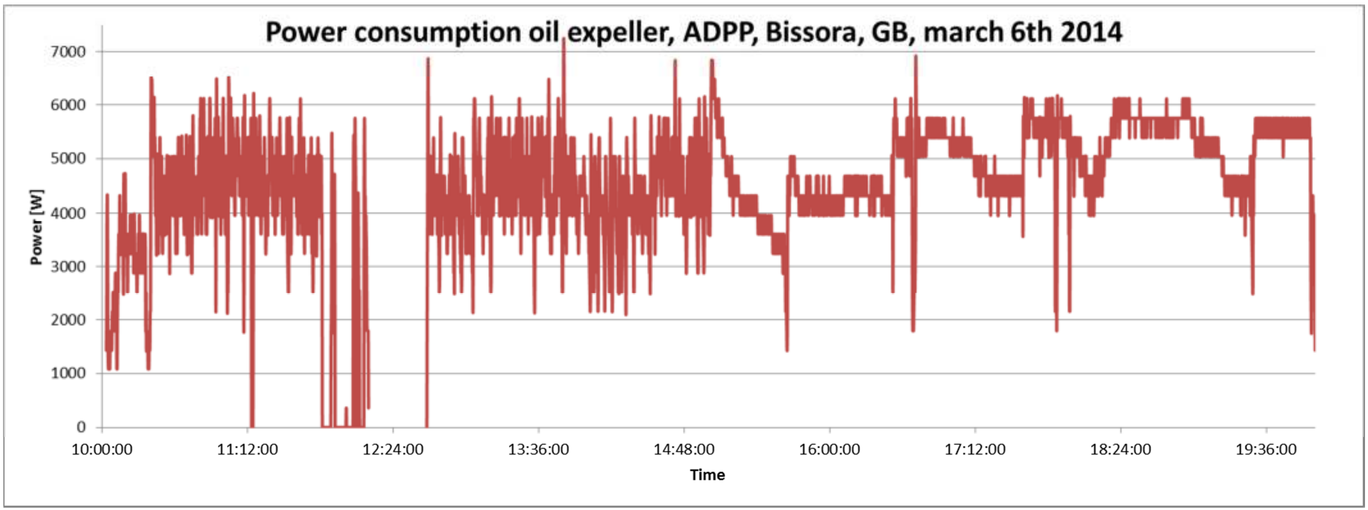
Thursday 6/3:

The Kamstrup electrical meter, which I brought on the first mission to GB in august 2013, was installed on a wooden plate and connected to 2 shorts 4x4mm2 cables with a female and male socket respectively, so that that the meter could be moved around to be inserted at the power supply for each electrical machine, to measure the power consumption. The USB data logger was connected to the impulse output from the meter and configured to save counts of power consumption for each 10 seconds, in order to measure the dynamic load of each machine. Each count from the meter is equivalent to 1wh.

Left photo: The meter with cables, socket and plug, and data logger.
Middle photo: The meter installed on the power supply for the maize mill.
Right photo: Detail of the meter and USB data logger.



Power consumption measured on the maize mill with the sieve with smallest holes for the finest flour. Note that power consumption is much higher than the 5,5kW nominal power of the motor. The load depends on the adjustment of the inlet to the mill, which was continuously controlled by the operator. It seemed challenging for him to control the load, partly because he didn´t recognize well the load of the motor from its sound, and partly because the maize and pearl millet mixture accumulated inside the mill because of the very fine sieve, so it caused some delay from changing the seed inlet speed and until the load on the motor was recognized.



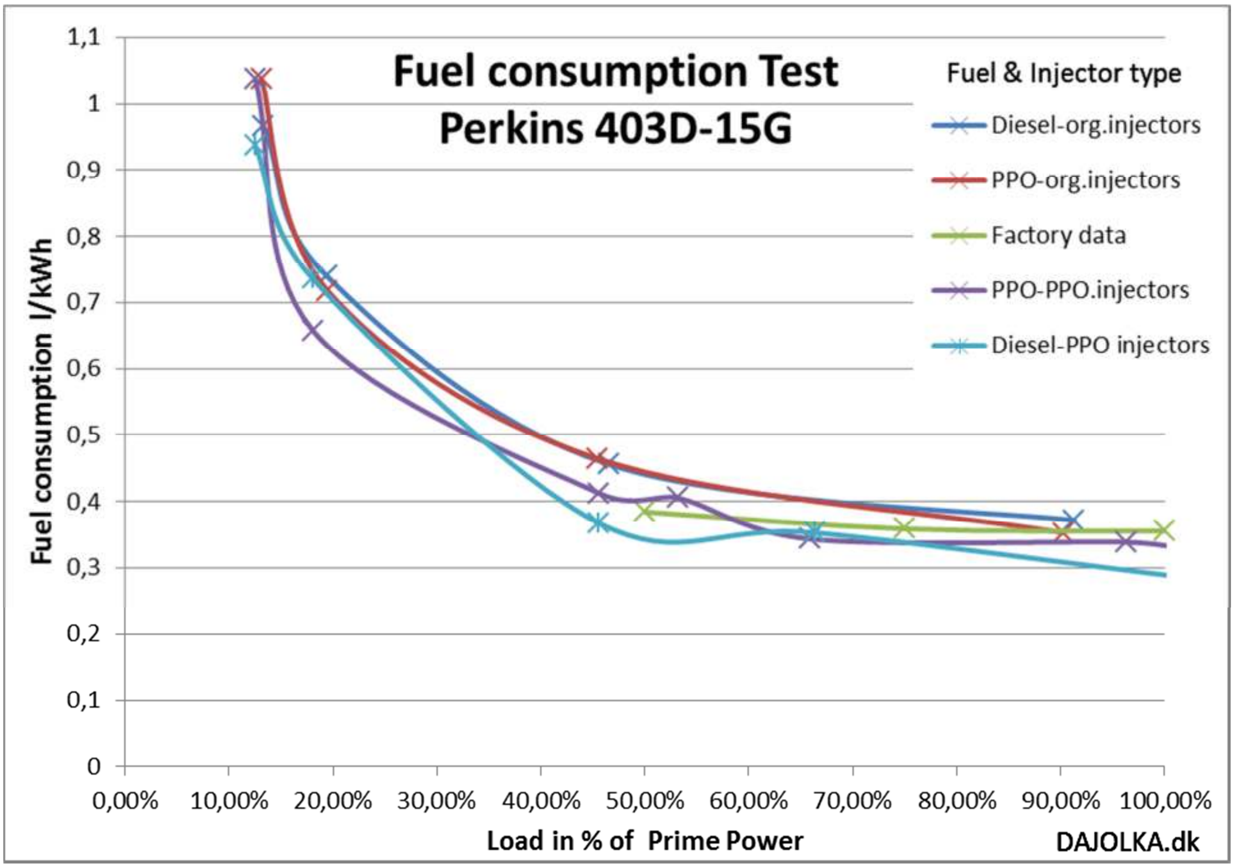
The curve shows the power consumption from the oil expeller during the whole day.

The genset was running most of the time from 10:00 in the morning until we left the site at around 21:00. The accumulated power consumption for both the oil expeller and maize mill was measured – total operation time 9h26m. Besides the genset was operated for illumination in the evening, and the freezer and approximately 5 light bulbs were turn ON the whole day. The power consumption of the freezer and light bulbs were not measured, but estimated.

The genset operator measured a consumption of 14,5 liter diesel during the whole day. The collected data are analyzed in the following table.

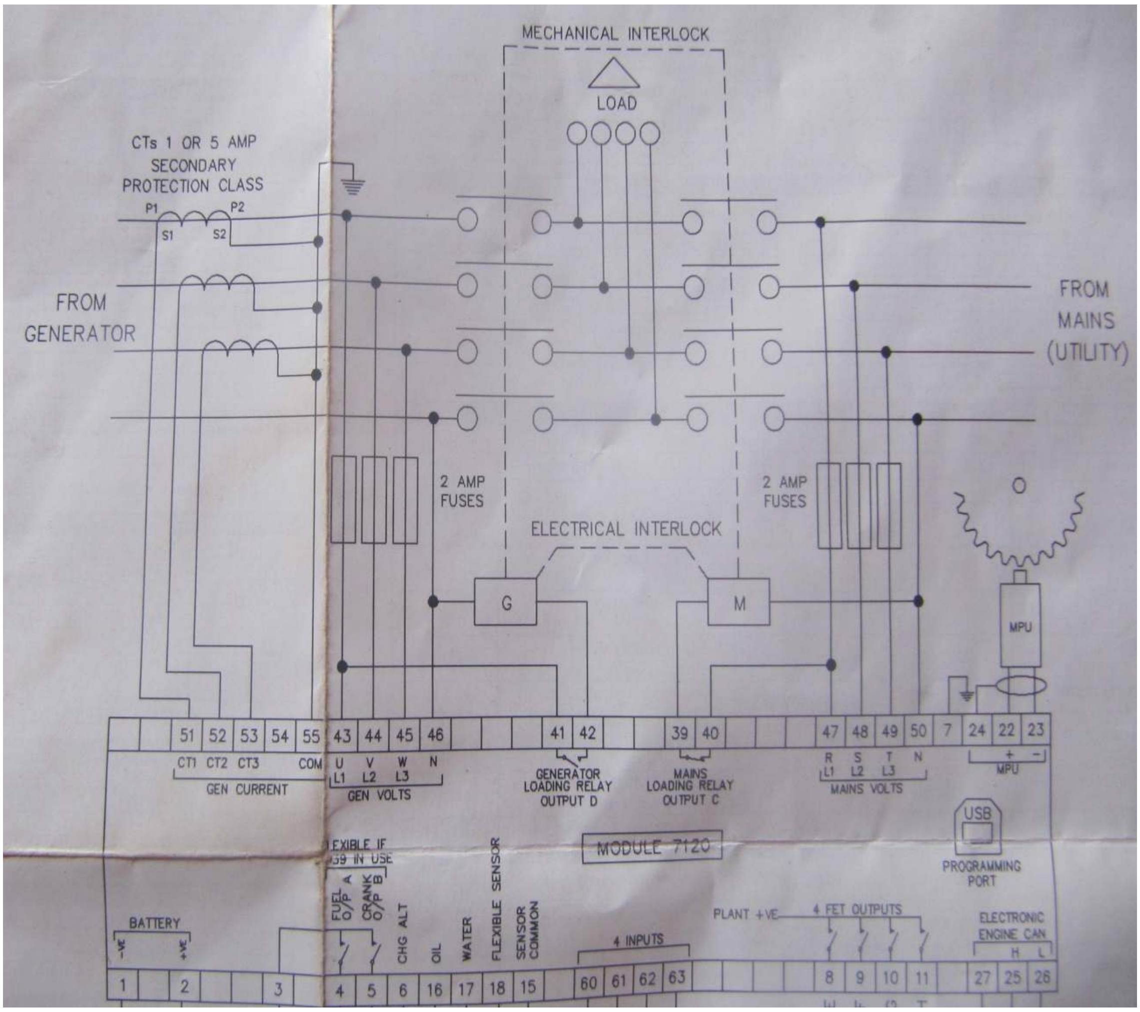
test ADPP, Bissora ,uinea Bissau, March 6th 2014		
total run time machines	hh:mm:ss	09:49:20
fuel consumption diesel	l	14,5
energy content diesel	MJ/l	35,9
energy content diesel	kWh/l	9,97
energy input fuel	kWh	144,6
energy consumtion machines	kWh	45,1
energy consumption light bulps, estimate	kWh	1,2
energy consumption freezer, estimate	kWh	1
total energy consumption	kWh	47,3
electric efficiency genset	%	32,7%
electricity production per fuel unit	kWh/l	3,26
fuel consumption per kWh	l/kWh	0,31
Genset electric capacity	kVA	13,5
Genset electric capacity	kW	10,8
average load genset	kW	4,59
average load genset	%	42,5%

The result shows that the load of the genset was 42,5% on average, and that the fuel consumption compared to the measured energy consumption gives a fuel consumption on 0,31 l/kWh, which is actually lower than what I have measured earlier on the genset in Denmark, and also lower than the factory data. At 42,5% load the fuel consumption is expected to be around 0,42l/kWh, or 1/3 more than we actually measured. So there might be some inaccuracy in the measurement of the fuel consumption during the day.

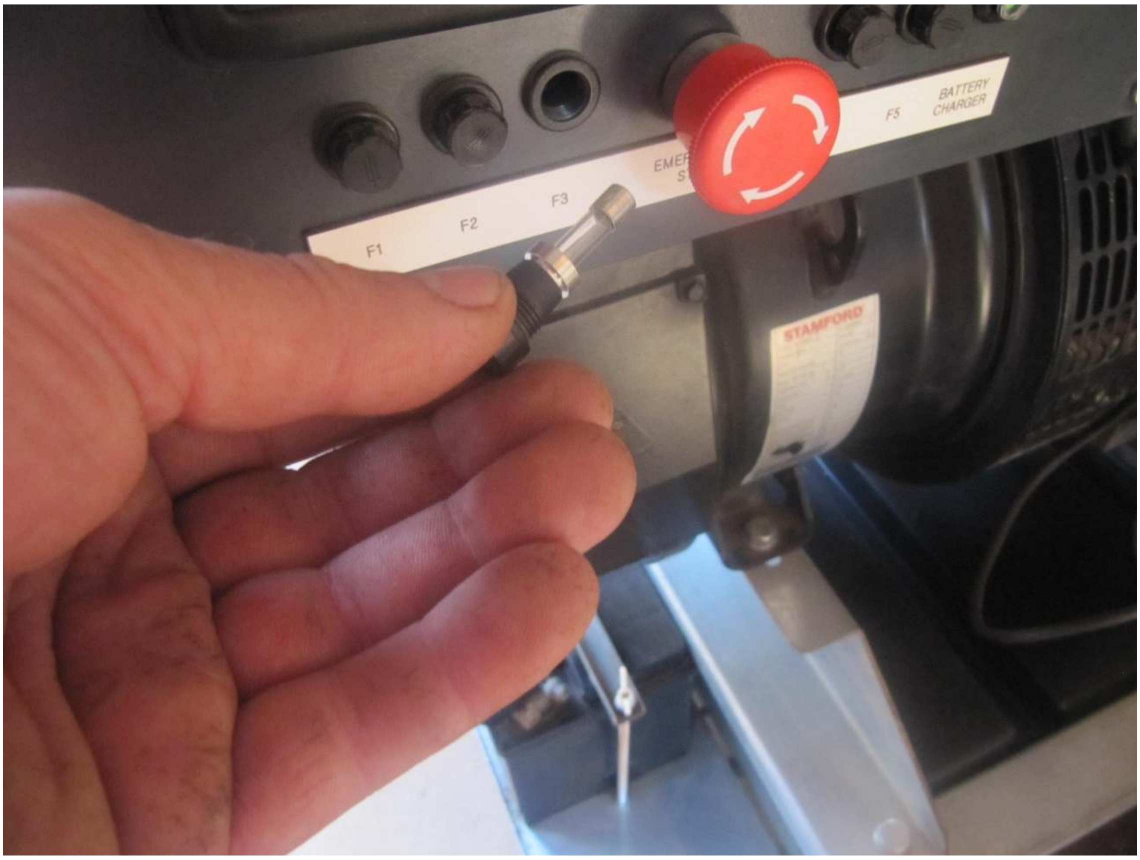


Fuel consumption measured on the genset in Denmark, with PPO and diesel, both before and after changing the injector nozzles.

In the afternoon we traveled to the village where the genset had error, stopping shortly after starting indicating low voltage on 1 phase.



First studied the electrical diagram

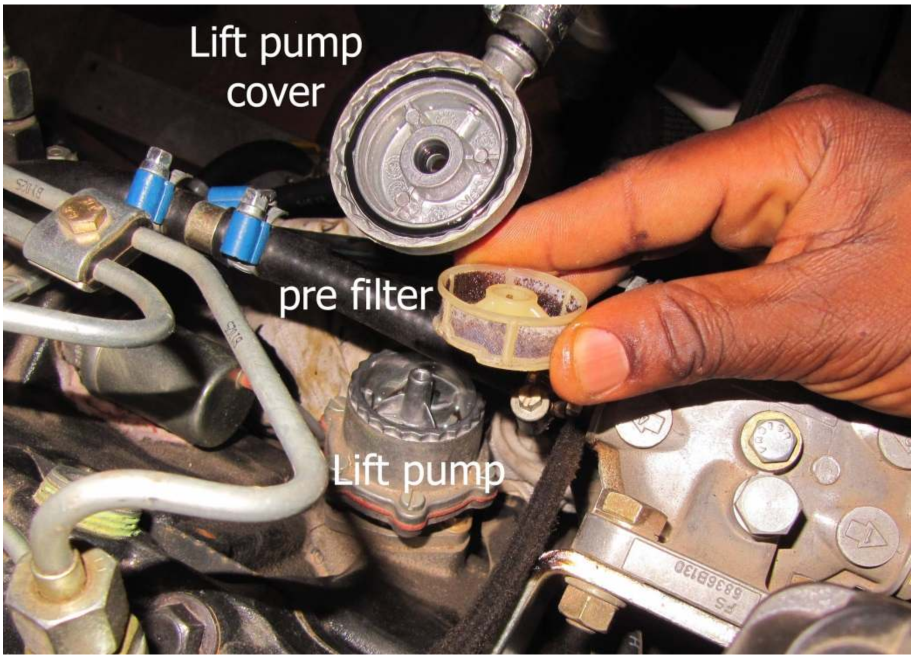


Found that the error was coursed by one of fuses which had become loose.

Friday 7/3

Working further with the oil expeller.

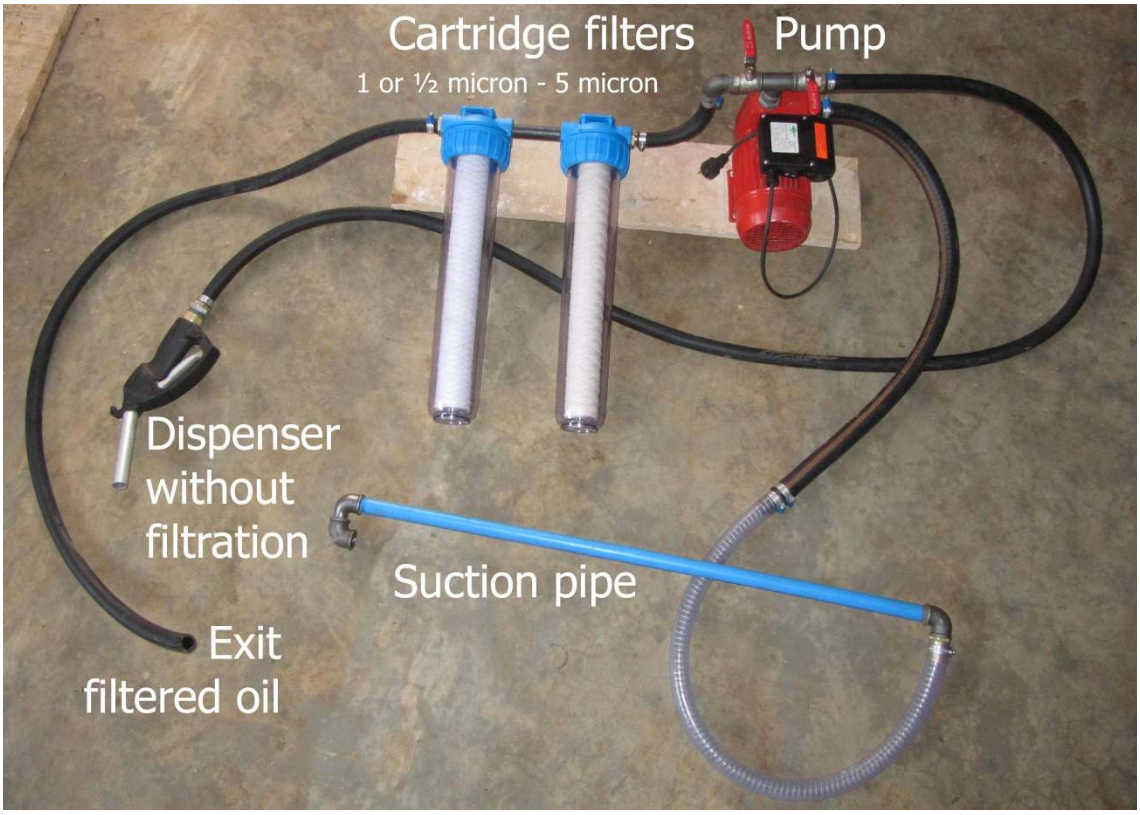
Training in removing the pre-filter from the lift pump on 1 of the gensets, and agree to have the pre-filter removed from the other genset.



Original pre filter integrated in the lift pump – to be removed for PPO operation.

Training in finding error on genset control system, when genset stops shortly after start, indicating low voltage on 1 phase.

Training in design and assembling filtration system with the electrical pump and cartridge filters.



The electrical pump and filter cartridges ready. The blue pipe is for suction of PPO from the sedimentation- or storage tanks. It can be pumped though the filter for safety fine filtrate 5 and 1 micron respectively, or the PPO can by-pass the filters and be delivered through dispenser, to fill canisters with clean oil.

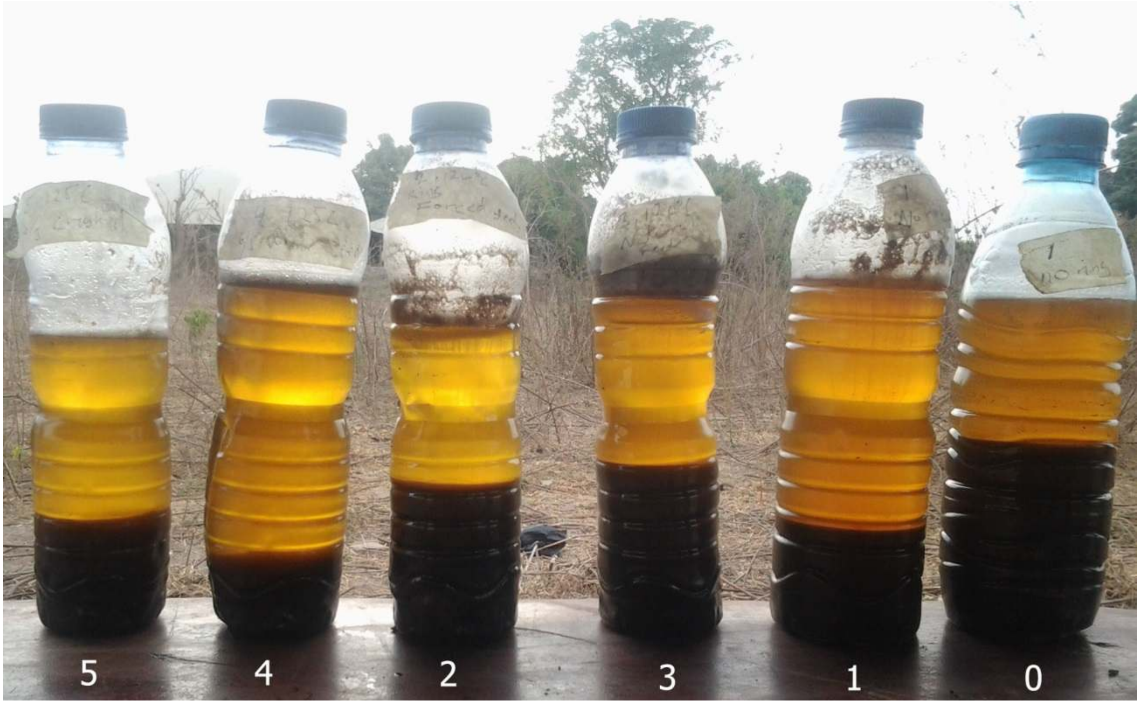
Saturday 8/3

Testing the electrical pump-filtrating system.

Training in analyzing the Jatropha oil samples for Free Fatty Acids (FFA) busing the field test equipment and ingredients brought from Denmark. (the alcohol was purchased in Bissau)

Testing the acidity of the PPO (FFA)

Collecting all oil samples and measuring the amount of dirt in % of the total output from oil expeller.



Preparing oil- , seeds and press cake samples to bring back to Denmark to have them analyzed in laboratory in Germany.

Around 15:00 leaving Bissora to go back to Bissau.

Meeting in ADPP office with Finn and Fernando etc.

Sunday 9/3

Start the return travel to Denmark with stop in Dakar.

Monday 10/3
Arrived at home 19:30

Niels Ansø - DAJOLKA

Fra:	Niels Ansø - DAJOLKA <niels@dajolka.dk>
Sendt:	26. maj 2014 14:32
Til:	'Pilirani Tembo'; 'Finn Jorgensen'; 'dappfceu@mweb.co.zw'
Cc:	'Fernando'; 'Joe Grove'
Emne:	result of oil analysis, conclussion about oil press.
Vedhæftede filer:	oil, cake and seed analysis.pdf; ASG_report_221799 copy.jpg

Dear Tembo and other colleagues at ADPP.

I got the final test report with the results from the laboratory a while ago.
Please find it attached. I have marked each result with a no. which I refer to later in the interpretation of the results.
I have also attached a graphical presentation of the results, including indication of the limits which applied to PPO fuel for your kinds of engines.

My immediate short comment are:
- moisture content of the seeds seems OK. (6)
- the laboratory get higher acid values than we measured in the field. I have same experience from DRC and India. The reason is most likely that the NaOH concentration is not constant and not exact, plus the fact that in GB and DRC we used ethanol based alcohol. Isopropanol is better to solve PPO.
- all the oil samples has too high acid value, phosphor and alkali content - it is really too high and this oil should not be used in the engines !!. (1,2,3,4,5). Se also the graphical presentation
- From the different oil samples there are large fluctuation in the quality, but initially it looks like the oil quality suffers from the handling in the oil press - it means when the oil press get very hot and press a lot of oil out, the oil quality also get bad. That means that the acid value, phosphor and alkali contents increases. The quality is worth when the oil expeller was not pressing constantly (1,3), which means that the cake and oil got stocked for a while inside the oil expeller, and then suddenly was released after a while. That corresponds well with normal experience with e.g. rape seed oil. That's why we always speak about cold pressing. I think that oil temperature of 120-140°C is really too much. I have discussed it also with the laboratory in Germany, and confirm that the FFA content in the extracted oil increases by increased pressing temperature, and that it increases more like exponential than linear.
- I have communicated with the oil press manufacturer (Double Elphant, China) to discuss if we should try to change gear exchange ratio of the screw, so reduce speed in order to reduce the amount of friction heat. His reply is that the oil expeller is designed for hot pressing, so that oil temperature at 120°C is normal. Its not designed for cold pressing. He also recommend to reduce size of seeds to same size as rice. It is also mentioned in the oil press manual, that it is designed for small seeds like sesam, colza etc.
- I got the last results from the lab which was focusing on the quality of the seeds. What they do is to press the oil of the seeds at low pressure and temperature, and immediately after that filter and analyze the oil. In this way we can see how is the quality of the oil when it is still inside the seeds, not giving the oil time to decompose and develop bad quality from the time it was pressed and until it will be analyzed in the laboratory. The result(6) shows that the oil only had an acid value of 0,517 mg KOH/g oil, corresponding a FFA content of 0,2585%, which is very low. The next result (7) was made from the exact same seed, but the oil was extracted by a solvent at 70°C, which imitates a more rough and hot process. The result was an acid value of 10,13 mg KOH/g oil, which corresponds a FFA content of 5,065 %. So my conclusion about the seed quality is, that the seeds are fine, and the problem is that the oil expelling is too rough and takes place a too high temperature. I have made the same kind of test of oil seeds from other projects, and there it sometimes shows that oil quality is also bad even when cold pressing in the laboratory. In these cases I conclude that the seeds are not good, e.g. if they were harvested too early so the seeds were unripe, or there are manu broken seeds. And in these cases I cannot conclude about influence from oil pressing conditions.

As mentioned it seems that the acid values we measured in the field by titration are lower than the results they get in the laboratory, and that I have got same experiences from other missions (DRC and India). I have come to the conclusion that the reason for the mismatch in the results most likely are caused my inaccurate concentration in the NaOH solution we use for the titration, and possible also problem by using ethanol based alcohol instead of isopropanol, while PPO is solved better in isopropanol and not so good in ethanol.

Conclusion about oil expeller:
- it is designed for small seeds like sesam, colza etc.
- it is designed for hot pressing - not cold pressing.
- it is very hard - nearly impossible to make it run with Jatropha seeds, and it is even more difficult to adjust how hard the expeller with press the oil.
- The temperature of the oil pressing get too high, and the cake too dry (very little oil left) The extracted Jatropha oil has far high too high values of acid (FFA), phosphor and alkali, even the oil seeds quality looks good with respect to FFA, moisture, oil content etc.

I cannot at this moment recommend another oil expeller which works good with Jatropha seeds, but in general I will recommend one with much larger screw and seed intake, and one which is designed to work slowly and low temperature, and if possible one which can change speed by change the pulleys, and or change motor to a slower one with 6 or 8 poles. It's even also possible to install frequency converter to control speed, but maybe it is not suitable in African contexts.

Med venlig hilsen / best regards
Niels Ansø
www.dajolka.dk , www.facebook.com/dajolka
WebShop: www.dajolka.net
+45 4014 8020

-----Oprindelig meddelelse-----
Fra: Niels Ansø - DAJOLKA [mailto:niels@dajolka.dk]
Sendt: 1. april 2014 11:14
Til: 'Pilirani Tembo'; 'Finn Jorgensen'; 'dappfceu@mweb.co.zw'
Cc: 'Fernando'; 'Joe Grove'
Emne: SV: SV: Training Program

Dear All

I´m still waiting the final test results from the Jatropha oil, press cakes and seeds from the ASG laboratory in Germany. I have got the preliminary results - only the cold pressing and analysis of the oil from the Jatropha seeds is missing.

I have attached the preliminary results.

My immediate short comment is:
- moisture content of the seeds seems OK.
- the laboratory get higher acid values than we measured in the field. I have same experience from DRC and India - and I´m trying to understand why.
- all the oil samples has too high acid value, phosphor and alkali content - it is really too high and this oil should not be used in the engines !!.
- From the different oil samples there are large fluctuation in the quality, but initially it looks like the oil quality suffers from the handling of the oil press - it means when the oil press get very hot and press a lot of oil out, the oil quality also get bad. That corresponds well with normal experience with e.g. rape seed oil. That's why we always speak about cold pressing. I think that oil temperature of 120-140°C is really too much.
- I communicate now with the oil press manufacturer to discuss if we should try to change gear exchange ratio of the screw, so reduce speed in order to reduce the amount of friction heat.
- now we are just waiting the last result from the laboratory. It can help us to understand if seeds contains good quality oil, or if the seeds can explain why the acid value is very high. Normally if the acid value is high already in the seeds, then also the phosphor and alkali contents gets too high.

Med venlig hilsen / best regards
Niels Ansø
www.dajolka.dk , www.facebook.com/dajolka

+45 4014 8020

-----Oprindelig meddelelse-----
Fra: Niels Ansø - DAJOLKA [mailto:niels@dajolka.dk]
Sendt: 11. marts 2014 19:30
Til: 'Pilirani Tembo'; 'Finn Jorgensen'; 'dappfceu@mweb.co.zw'
Cc: 'Fernando'
Emne: SV: SV: Training Program

Dear All

I returned well to home yesterday evening.

Today I have sent all samples to the laboratory in Germany. I think result will come last half of next week.

It was really great to work with you in Guinea Bissau.
The workshop was very well organized, and there was a good team spirit.
I will come back to you soon - thanks.

Med venlig hilsen / best regards
Niels Ansø
www.dajolka.dk , www.facebook.com/dajolka
+45 4014 8020

-----Oprindelig meddelelse-----
Fra: Pilirani Tembo [mailto:cesdo7@yahoo.com]
Sendt: 1. marts 2014 17:13
Til: 'Finn Jorgensen'; dappfceu@mweb.co.zw; Niels Ansø - DAJOLKA
Cc: 'Fernando'
Emne: Re: SV: Training Program

Dear Niels
It is really very un luck, but we hope today you will make it to Guinea Bissau.
And the Person waiting for you at the airport is Suleimane Danso together with the driver from the project, in fact we will need to again organise with the program so that we have achieve our goal together.
Hoping to see you soon in Bissora.
best regards
Pilirani K Tembo.

On Sat, 3/1/14, Niels Ansø - DAJOLKA <niels@dajolka.dk> wrote:

Subject: SV: Training Program
To: "'Finn Jorgensen'" <fij@humana.org>, dappfceu@mweb.co.zw
Cc: "'Fernando'" <adppfb@eguitel.com>, "'Tembo'" <cesdo7@yahoo.com>
Date: Saturday, March 1, 2014, 12:30 PM

Dear Finn OK, thanks. Yes, we are really unlucky. The time in the airport was very wasteful because it took the airline a lot of time to send us to a hotel.
Finally we took a taxi on our own. It gave me time to speak to the other passengers. There are 2 gentlemen from the World Bank who has visited ADPP and Bissora – one of them from US (he look like Indian), and the other from Mozambique – I think the last knows Asger from his time in Mozambique. They both speak very positive about ADPP. Med venlig hilsen / best regardsNiels Ansø www.dajolka.dk , www.facebook.com/dajolka
+45 4014 8020 Fra: Finn Jorgensen [mailto:fij@humana.org]
Sendt: 1. marts 2014 10:10
Til: 'Niels Ansø - DAJOLKA';
dappfceu@mweb.co.zw

Cc: 'Fernando'; 'Tembo'
Emne: RE: Training Program Message receivedWe are really unlucky.This period of the year is really windy.Finn From: Niels Ansø - DAJOLKA [mailto:niels@dajolka.dk]

Sent: Saturday, March 01, 2014 5:57 AM
To: dappfceu@mweb.co.zw
Cc: 'Finn Jorgensen'; 'Fernando';
'Tembo'
Subject: SV: Training
Program
Dear all I was ready to leave the Hotel just now, but got the information that the plane has been postponed for 18:00. Yesterday we was near to land in Bissau, but the pilot decided to take off again and go back to Dakar. He told it was bad visibility because of dust/sand. Do you know what is the reason for the dust? I noticed on the palm trees leaves that it was windy. Med venlig hilsen / best regardsNiels Ansø www.dajolka.dk , www.facebook.com/dajolka
+45 4014 8020 Fra: Niels Ansø - DAJOLKA.dk [mailto:niels@dajolka.dk]

Sendt: 28. februar 2014 20:26
Til: Niels Ansø - DAJOLKA.dk; dappfceu@mweb.co.zw
Cc: 'Finn Jorgensen'; 'Fernando';
'Tembo'
Emne: RE: Training Program Dear all The plane was canceled and we will try again tomorrow morning 8:00.Best regardsNiels

Med venlig hilsen
Niels Ansø
DAJOLKA.dk
(sendt fra mobil)

"Niels Ansø - DAJOLKA.dk"
<niels@dajolka.dk> skrev:

Just to let you know that everything is going fine in Dakar I will come as planned in about 2 hours from now. See you soon

Med venlig hilsen
Niels Ansø
DAJOLKA.dk
(sendt fra mobil) No
virus found in this message.
Checked by AVG - www.avg.com
Version: 2014.0.4259 / Virus Database: 3681/7011 - Release
Date: 01/17/14
Internal Virus Database is out of date.No virus found in this message.
Checked by AVG - www.avg.com
Version: 2014.0.4259 / Virus Database: 3681/7011 - Release
Date: 01/17/14
Internal Virus Database is out of
date.

Trentiner Ring 30 • D-86356 Neusäss / Germany

DAJOLKA
Dalmosevej 2
DK-9330 Dronninglund

your reference : Ansø
your order-no. :
date of order : 11.03.2014
sample receipt : 14.03.2014
sampling : Customer
report date : 04.04.2014
page : 1 of 1

Report-No. : 221799

	Sample	ASG-ID	Parameter	Method	Result	Unit
1)	Jatropha Oil 1	252739	Acid value	DIN EN 14104	16,53	mg KOH/g
			Phosphorous content	DIN EN 14107	148	mg/kg
			Earth alkali content (Ca + Mg)	DIN EN 14538	72	mg/kg
2)	Jatropha Oil 2	252740	Acid value	DIN EN 14104	7,50	mg KOH/g
			Phosphorous content	DIN EN 14107	117	mg/kg
			Earth alkali content (Ca + Mg)	DIN EN 14538	62	mg/kg
3)	Jatropha Oil 3	252741	Acid value	DIN EN 14104	12,52	mg KOH/g
			Phosphorous content	DIN EN 14107	162	mg/kg
			Earth alkali content (Ca + Mg)	DIN EN 14538	79	mg/kg
4)	Jatropha Oil 4	252742	Acid value	DIN EN 14104	8,19	mg KOH/g
			Oxidation stability 110 °C	DIN EN 14112	23,8	h
			Phosphorous content	DIN EN 14107	130	mg/kg
			Earth alkali content (Ca + Mg)	DIN EN 14538	60	mg/kg
5)	Jatropha Oil 5	252743	Acid value	DIN EN 14104	7,82	mg KOH/g
			Phosphorous content	DIN EN 14107	127	mg/kg
			Earth alkali content (Ca + Mg)	DIN EN 14538	57	mg/kg
6)	Jatropha Seeds	252744	Acid value	DIN EN 14104	0,517	mg KOH/g
			Oil content	DIN EN ISO 659	32,8	% (m/m) om
			Water content (Humidity) seeds	DIN EN ISO 665	7,6	% (m/m) om
7)	Extracted oil from ID 252744	254185	Acid value	DIN EN 14104	10,13	mg KOH/g
8)	Jatropha press cake 1	252745	Oil content	DIN EN ISO 659	3,4	% (m/m) om
9)	Jatropha press cake 2	252746	Oil content	DIN EN ISO 659	8,3	% (m/m) om
10)	Jatropha press cake 3	252747	Oil content	DIN EN ISO 659	5,0	% (m/m) om
			Ash content (550 °C)	DIN EN 14775	6,0	% (m/m) dm
			Water content (Humidity) seeds	DIN EN ISO 665	6,3	% (m/m) om
			Calorific value, upper	DIN 51900-1 mod.	20986	J/g dm
			Calorific value, lower	DIN 51900-2 mod.	19652	J/g dm

om = Result relating to original matter
dm = Result relating to dry matter

J. Bernath

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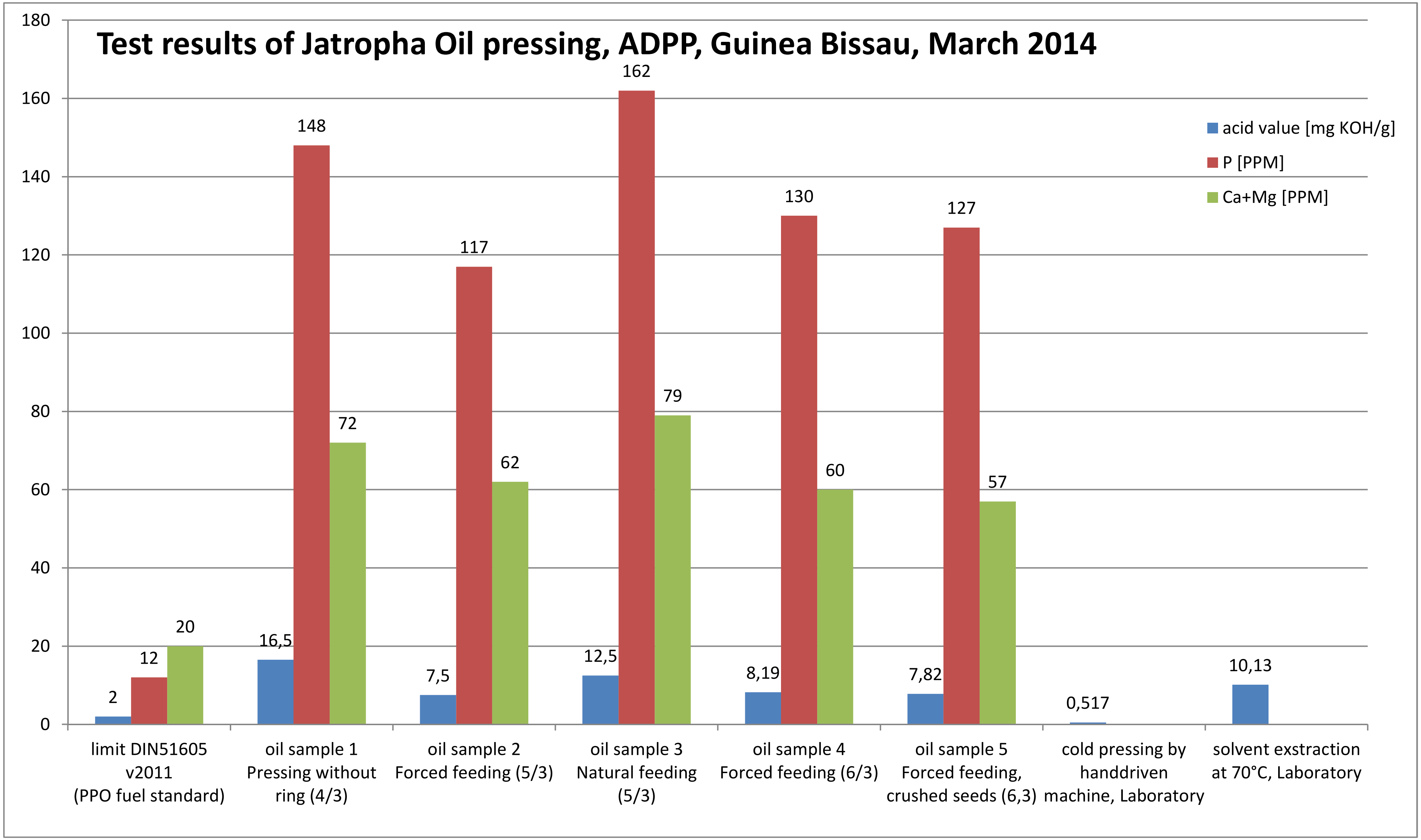

Test results of Jatropha Oil pressing, ADPP, Guinea Bissau, March 2014
180
160
140
120
100
80
60
40
20
0
acid value [mg KOH/g]
P [PPM]
Ca+Mg [PPM]
2
12
20
16,5
148
72
7,5
117
62
12,5
162
79
8,19
130
60
7,82
127
57
0,517
10,13
limit DIN51605 v2011 (PPO fuel standard)
oil sample 1 Pressing without ring (4/3)
oil sample 2 Forced feeding (5/3)
oil sample 3 Natural feeding (5/3)
oil sample 4 Forced feeding (6/3)
oil sample 5 Forced feeding, crushed seeds (6,3)
cold pressing by handdriven machine, Laboratory
solvent exstraction at 70°C, Laboratory

3.3 Fuel quality

It is generally accepted that the German norm for rape seed oil as engine fuel, DIN51605, should apply to pure vegetable oil used as fuel in converted diesel engines. The norm specifies 8 natural parameters, which are more or less specified by nature, and 7 variable parameters, which are influences by harvest, handling and storing of the oil seeds, and by the process, handling and storing of the oil. For other vegetable oils than rape seed oil, the DIN51605 can be used as general reference, but each crop might have different natural and variable parameter relevant to PPO as a fuel.

The purpose of the quality standard is to ensure that the vegetable oil do not contain components and impurities which will weakening its own storing stability, and to limit the level of "strangers" in the fuel, which can negative impact on the combustion efficiency and leading to increased emission level and deposits in the engine, as well as avoid properties which can damage the injection system.

The norm has been updated several times – the latest version came into force from January 1st 2012, taking into account the newest European emissions norms, and the fact that most new passenger diesel cars on the European market are equipped with particulate filters, which make the engines very sensitive to contents of ash components like Phousphour(P), Calcium(Ca) and Magnesium(Mg) in the fuel. As a consequence of the latest update, rape seed oil produced by cold pressing and filtering alone, can no longer meet the limits for these parameters – its necessary to reduce the level of P, Ca and Mg by additional semi refining. But for engines without particulate filter, which in Europe are most engines produced before around 2005, and most engines in rural areas in developing countries, the previous version of DIN 51605, valid until 31/12 2011, can be used. This quality can normally be achieved just by careful cold pressing and filtering.

3.3.1 DIN V 51605(2011) – Quality Standard for Rape Seed Oil as engine fuel

The limits specified in DIN V 51605 (2011)[3)] is displayed in the table below. As indicated this is the version of the standard which was valid until December 31st 2011. These are limit are relevant to most engines found in developing countries.

Parameter	**Limit**	**Unit**
Characteristic/natural properties [1)]		
Density at 15 °C	900 - 930	kg/m³
Flashpoint Pensky- Martens	min. 101	°C
Kinematic viscosity at 40 °C	max. 36,0	mm²/s
Calorific value (incl. H2O –Correction)	min. 36.000	kJ/kg
Cetane number	min. 40	-
Carbon residue CCR (from Original)	max. 0,40	% (m/m)
Iodine number	95 - 125	g Jod/100 g
Sulfur content	max. 10	mg/kg
Variable properties [2)]		
Total contamination	max. 24	mg/kg
Acid number	max. 2,0	mg KOH/g
Oxidation stability	min. 6,0	h
Phosphorus content	max. 12	mg/kg
Earth alkali content (Ca + Mg)	max. 20	mg/kg

Ash content	max. 0,01	% (m/m)
Water content	max. 0,075	% (m/m)

1) The natural properties which are independent from the process, handling and storing.
2) The variable properties which are influenced by the process, handling and storing
3) A new version of DIN 51605, with reduced limits for ash building components, were introduced by January 1st 2012, especially to meet requirements for the newest type diesel engines with particulate filter installed. The limits in the table above are from the DIN norm before January 1st, and are suitable for diesel engines without particulate filter.

The following parameters are the most important for a safe operation of diesel engines on PPO.

3.3.2 Water content

Water can emulsify in PPO up to approximately 0,1% (1000PPM). Above this limit, water can separate from the PPO as free water which can damage the injection system by corrosion, and degrade the storage stability of the PPO, leading to increase acid no. of the PPO due to Hydrolysis [2]. In order to avoid free water in PPO fuel, the limit is set at 0,075% (750PPM), to keep some distance to the saturation point of emulsified water in PPO.

In most cased the water content is in vegetable oil is low, and if free water is found, the reason is most likely water contamination from outside coming sources. Sometime the water limit is exceeded due to high amount of phosphor, while the phosphor lipids acts like emulsifier between water and vegetable oil.

3.3.3 Acid no. / content of Free Fatty Acids (FFA):

The Acid no. expresses the amount of Free Fatty Acids in the vegetable oil, and is one of the most critical parameters when using vegetable oil as fuel in diesel injection system. One major problem is that vegetable oil with high level of FFA becomes abrasive to sensitive component in the fuel injector nozzles and to the fuel injection pump, which can generate permanent problems for the engine performance - very rapidly if the Acid no. is high, which means more than approximately 4 mg KOH/g. Another problem is that vegetable oil with high acid value reduces the stability of the lube oil, due to dilution of the lube oil by unburned vegetable oil. If the injection system is damaged the engine will burn the fuel less efficient, and more unburned PPO will dilute the lube oil (and generate deposits in the engine), so the problem will emphasize itself.

Its not possible to see, smell or taste on the vegetable oil if the acid no. is too high.

The Acid no. is determined by titration, where it is possible to measure the amount of FFA. There exist a stoichiometric relation between the acid no. and FFA level. 1% FFA corresponds an acid no. of 2,0 mg KOH/g PPO, or 2,85 mg NaOH/g PPO, dispending on if the titration solution is based on KOH or NaOH. Titration can be done in the field to get a good impression of the level, but it is advised from time to time to have the results confirmed by a professional laboratory.

The Acid no. is influenced by hydrolysis (by presence of free water)[2], enzymes[3], catalysts like cobber(Cu)[2], oxidation by contact to atmospheric air, light/sun radiation, fungi's etc.

3.3.4 Phosphor content

Phosphor is a stranger in the combustion process, and lead directly to an increase emission of P related particles in the exhaust, and P related deposits in the engine, which has an abrasive behavior. And it leads indirectly to an increase of unburned fuel duel to a reduction in the combustion temperature. The limit in the DIN51605 v2011 fuel standard is 12 PPM.

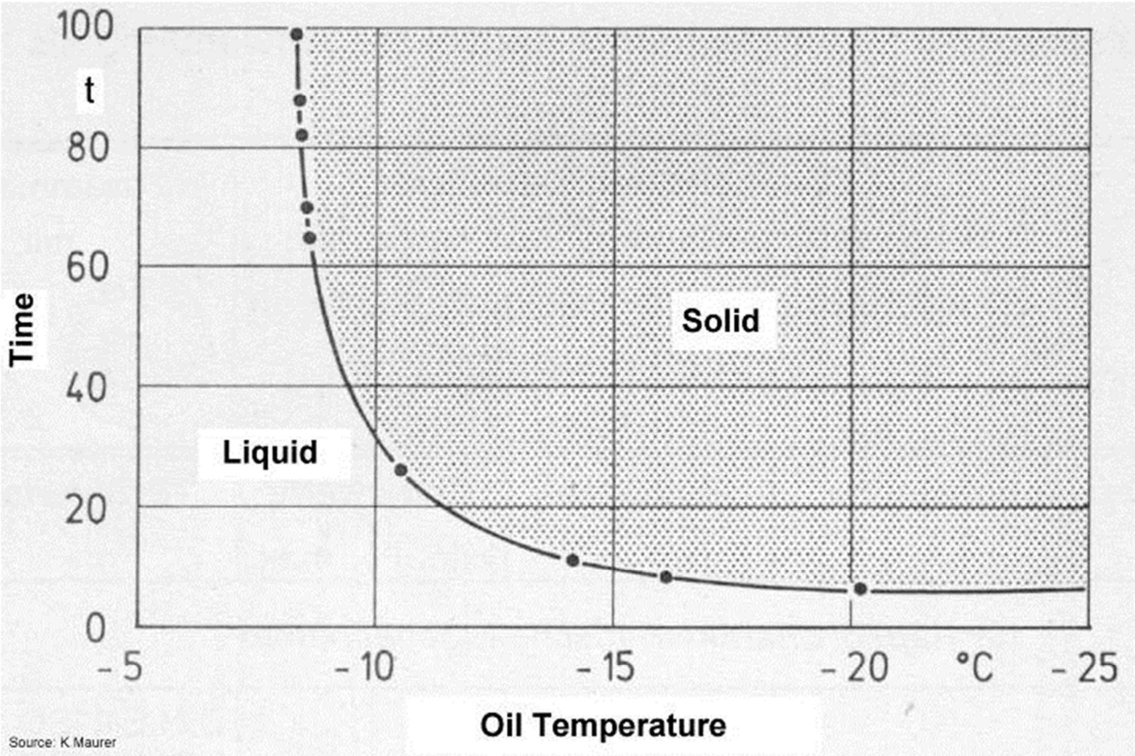
3.3.5 Alkali content (Ca+Mg)

As with phosphor, alkali components Ca and Mg, are strangers in the combustion process and should be kept at a low level. We have very often experienced that low alkali contents is found together with low content of phosphor, so therefor we normally only test the oil for phosphor, and only if it is very important for the documentation of the quality, we also test it for alkali content. The limit in the DIN51605 v2011 fuel standard is 20 PPM.

3.3.6 Melting point

The melting point of PPO depends on the source of the vegetable oil, and is normally only relevant to care about if the application operates at temperatures below the melting point of the fuel, e.g. approximately 5-10 °C for Jatropha oil, or around 35-40°C for Palm oil.

The phase shift from liquid to solid vegetable and back happens as a function of both temperature and time. The following curve shows this relation for rape seed oil. The tendency will be the same for other kinds of vegetable oil, but the temperature range at which the phase shift happens, will be different for each kind of oil.



Solid/liquid phase shift of rape oil as function of temperature and time.

3.3.7 Contamination

The limit for contamination with impurities is 24mg/kg (24PPM), which is quite low. The purpose is to avoid blocking of fuel filter, but also to avoid unnecessary wear on injectors nozzle and injection pump. PPO can easily contain 4-6 times more impurities, which are not visible for the eye, and which will not sediment in a sample. Therefor it is highly recommended always to pass the PPO though a fine filtration system to be sure that the limit for contamination is not exceed. From German research we have learned that cartridge filters with cartridges made from cotton string is the most efficient for filtration of vegetable oil. Its best to do the filtration in 2 steps, with a 5 micron cartridge first, followed by 1 or ½ micron for the last step.

3.3.8 Alkaline metals(Na,K)

The content of Alkaline metals(Na,K) in vegetable oil is not mentioned in the DIN51605 standard, while it is normally not relevant for PPO as fuel. But it could be relevant for this project in case a high acid no. has to be reduced by a saponification process to remove Free Fatty Acids(FFA), using NaOH to neutralize the FFA´s. The FFA´s are converted to soap, which should be removed by gravity separation and filtration.

Alkaline metals(Na,K) can be present in the vegetable oil as free NaOH or KOH left from the saponification process, or as integrated part of soap created from the same process.

Since standards for Biodiesel (trans esterified vegetable oil) includes limits for alkaline metals(Na,K), we suggest to use these limits. Several Biodiesel standards from different countries are published in Gelbes Heft 69(page 34)[4], specifying 5-10 PPM as limit, and the ASTM standard for biodiesel specifies 5 PPM as limit [6].

We suggest to use 5 PPM as limit for Alkaline metals(Na,K).

3.3.9 Soap content

The soap content in vegetable oil is not mentioned in the DIN51605 standard, while it is normally not relevant for PPO as fuel. But for this project it could become relevant if a saponification process is applied to remove Free Fatty Acids(FFA), using NaOH to neutralize the FFA´s. The FFA´s are converted to soap, which should be removed by gravity separation and filtration.

The soap content is relevant for Biodiesel (trans esterified vegetable oil) quality, because saponification processes are a part of the biodiesel manufacturing process. Nevertheless we have not found limits for soap content mentioned directly in Biodiesel quality standards.

A limit of 50 PPM (0,005%) soap is mentioned in the ALINORM 99/17 in Gelbes Heft 69(page 39) [4]. And soap limits can be calculated according to the ASTM limits for Alkaline metals(Na,K) [5]. If NaOH is used to neutralize the FFA´s, the limit for soap is calculated to 41PPM.

We suggest using 40 PPM as the limit for soap.