Design and Realization of a Pilot System for the Production of Gas and Very Low Voltage Electric Current using Biodiesel from the Recovery of Used Edible Oils

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Abstract: ***In recent years, international issues have mainly focused on energy issues and environmental preservation. Energy production from fossil resources accounts for more than 70% of total global energy production with negative environmental impacts. this work focuses on used edible oils, the impacts of which pose a problem for our environment; the spillage of one liter of these oils is estimated at 1000 m2 of oily film on the surface of the water, thus preventing proper oxygenation of the latter. The objective of this study was to design and build a pilot system for the production of gas and very low voltage electricity using biodiesel from the recovery of used cooking oils. The methodological approach here has a particular interest for the methods of transesterification and thermoelectricity by Seebeck effect, implemented in real life after digital simulation of the system, for the realization of the pilot system. The results obtained show that the KOH catalyst has much more advantage than NaOH where we obtained a percentage of glycerin (34%). The highest yield (89.82%) is obtained with the KOH catalyst at a temperature of 65° C., a molar ratio of 6: 1 and a reaction time of 120 min; and in the electricity production phase, the results were low (5 volts) due to the thermoelectric components which have low voltage production efficiency and wind flows in the environment of the pilot system causing inconstancy of the flame leading to poor heating of the different modules. A constructive voltage boost solution has been provided to compensate for this variation in the heat flow in order to have a considerable voltage; this allowed us to reach 48 volts.***

Keywords: Renewable energies; Biodiesel; Thermoelectricity; transesterification

1. Introduction

In a context marked by soaring fuel prices with a record of 146 US dollars per barrel, July 3, 2008(the price of a barrel of oil exceeds 146 dollars, 2008), 125 US dollars in 2022 and by forecast statistic 150 US dollars in 2023 (the official oil price, 2022), global warming due to greenhouse gases (more than 1 million kilos of CO_2 emitted into the atmosphere(planetscope, 2018)); the development of biofuels and the search for alternative energy sources is necessary. The use of used edible oils as fuel (biodiesel) and waste heat as a source of electricity production (thermoelectricity) in industrial production units or any other fuel and/or electrical energy consumption system is promoted by certain actors and presented as a powerful driving force in the development of these sectors and almost exploitable leads that should contribute to improving the approach put in place for environmental preservation and sustainable development.

Faced with this contextualization, the following problems are considered:

- The dumping of used cooking oils into the environment which forms a greasy film on the surface of the water and prevents the oxygen in the air from penetrating it. This phenomenon is felt when studies show that one liter of oil is enough to form a film of 1000 m² on the surface. (Sylvain, 2019).
- Diminishing fossil fuel resources; due to its overexploitation in the world, particularly in the transport sector (Copinchi, 2010). By dint of exploitation, these riches offered by nature are in a state of exhaustion (Planet, 2021).
- The energy deficit translates into the insufficiency and disturbances of the energy produced by various factors(Akon Lighting Africa, 2018).

According to an overall observation, the parties with major involvement in these findings are in particular: food industries, restaurants, households, motorists, fuel - consuming businesses, etc.
Through a series of observations, we notice a strong manifestation of these harmful impacts in Africa in the case of Cameroon (place of the study) generally manifesting itself by:

- Pollution of soils and aquatic environments,
- the rapid depletion of fossil resources,
- Permanent non - accessibility to electrical energy in developing countries.

In order to protect the environment (ecosystems), reduce the release of greenhouse gases, preserve natural resources due to the significant frequency of training, improve access to electrical energy for populations in deficit through research alternative sources of fuel and electricity production, this work was centered around a main question, namely:

- Whether the energy recovery of used cooking oil can be a solution to reduce environmental pollution and save natural resources in a perspective of sustainable development?

Secondary research questions:

- How can the amount of used cooking oil released into the environment be kept to a minimum?
- Is it possible to develop and use an alternative energy source with similar characteristics and less polluting to save the remaining fossil fuel?
- What other rational, affordable means can be implemented to support accessibility to electrical energy in Africa, particularly in Cameroon?

The objective for us will be to design and build a pilot system for the production of gas and electric current TBT by biodiesel from the recovery of used cooking oils.

Specifically, it will be about:

- Set up a collection approach for used edible oils in the different production areas;
- Synthesize used food oils into biofuel (biodiesel) through a transesterification reaction;
- Design and build a pilot system for the extraction of gas from the synthesis of biodiesel (B60) and thermoelectric recovery for the production of a very low voltage electric current (TBT) from the combustion of the extracted gas.

Many methods in the field have been developed by biodiesel production researchers and scientists around the world. There is no need here to mention all these methods but we will endeavor to cite the relevant results of some works of interest to us in our present study.

Table 1: Some studies carried out in the production of Biodiesel

Works	Goals	results
(REFAAT.AA, ATTIA.NK, SIBAK.HA, SHELTAWY.ST, & ELDIWANI.GI, 2008)	optimizing the production and evaluating the quality of biodiesel produced from domestic frying oils and restaurants.	**Molarratio**: (methanol/oil) = 6: 1 **Catalyst**: KOH (1%) **Temperature/time**: 65°C/ 1h **Yield**: 96.15% in optimal conditions
(Oguntola, Waheed, & Jekayinfa, 2007)	study on the optimal duration of the transesterification of palm kernel oil for the production of biodiesel	**Alcohol:** 20% ethanol (from oil mass). **oil mass:** 100g **Catalyst**: KOH (1%) **Temperature/ time**: 60°C/30; 45; 60; 90; 120 mins **Yield**: 87.4; 90.1; 92.5; 94.2; 96.0; 96.0 and 96.0%. The best performance was obtained after a time of 90 min.
(Tint & Mya, 2009)	produce Jatropha oil biodiesel from methanol and ethanol	**Molar ratio:** 6: 1 and 8: 1. **Catalyst**: 1% NaOH and KOH, **Temperature/ time**: 65°C/ 1h and 5h **Yield**: 96.15% in optimal conditions

2. Methodology

The framework of this study was to make a scientific and technological experimental contribution to:

The recovery of waste of food origin, more specifically used vegetable oils into biodiesel, by mixing the used oil (triglyceride) and alcohol (methanol or ethanol) with a catalyst to speed up the reaction time.

- The modeling and production of a gas extraction prototype which will result from the synthesis of biodiesel (B60), where the main elements highlighted in the process will be: water, air and the cut of the biofuel in himself.
- The realization of a prototype for the recovery of Joule effect losses generated by motors and all other heat generators, for the production of very low voltage electrical energy.

2.1 Methods of Valorization of used cooking oils in Biodiesel

2.1.1 Oil Collection Methodology

The proxy operation for used vegetable oils for cooking was carried out with potential producers of this waste, who most of the time do not know what to do with it; this regularly due to the enormous quantities produced or to a policy of use specific to the user and to a health aspect (according to which the oils used twice should no longer have a third use because it can have negative impacts on the health of the consumer; therefore, it should be discarded). The potential producers to which we will focus are Food factories (production of fried foods such as plantin, apples, etc.); Restaurants (hotels and individuals); Households. With strategic and technical means of deployment such as:

- Subscribing to potential producers of used oils (food factory, restaurants, supermarkets) and communicating with them about the vision.
- Establishment of a collection schedule varying according to the productions

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- The installation in all collection places of collection containers (tanks connected with an alert system, mobile and hermetic containers)
- The establishment of a logistics system for collection (oil recovery trucks once in the containers; vans; bicycles, etc.)
- proceed by means of rewards for each return of used cooking oils to collection points (a town hall, or any other place chosen for this purpose) in the case of households.

2.1.2 Transformation of used cooking oils into Biodiesel.

Biodiesel is an alternative fuel to Petro - sourced diesel obtained by a chemical reaction highlighting fat and alcohol in the presence of a catalyst. Such a reaction product is obtained by the following general steps:

Step 1: settling and filtration of used oils collected used oils)
Before it can be processed, the used oil must first be filtered to clean it of any food residues (chips, doughnuts, etc.). It is advisable to let the oil settle for a few days.

Step 2: transesterification reaction
reacting oil with an alcohol (methanol or ethanol) and a catalyst (sodium or potassium hydroxide) at a temperature (θ) for a time (t) in order to obtain methyl or ethyl esters (biodiesel) and a by - product, glycerin.

Step 3: separation of glycerol
Drain the glycerol from the bottom of the separating funnel into a new container. Pay attention to what remains of glycerin in the biodiesel. Keep the glycerol obtained.

Step 4: Washing and drying of biodiesel
Very slowly add 20% of the volume of biodiesel in washing solution to avoid the formation of soap and wait 10 min. Drain the Wash water.

Step 5: Glycerol treatment (optional)
The recovery of the methanol contained can be carried out by distillation of the glycerol, that is to say by heating the glycerol to a temperature above 65° C., the boiling point of methanol. The methanol vapors must then pass through a condenser, cool and be collected as a liquid at the outlet.

2.2 Method of extraction and production Gas from the synthesis of Biodiesel (B60)

Gas extraction consists of producing Gas from the synthesis of biodiesel mixed with 40% conventional diesel by a simple mechanism. The extraction mechanism is based on a principle identical to that of the functioning of the human heart; the principle of the one - way valve. This reaction reveals compressed air, water and biodiesel (B60).

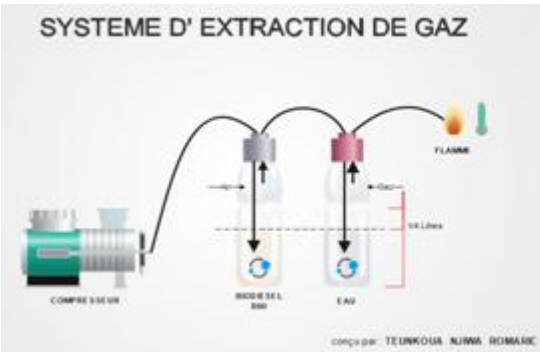

Figure 1: Gas extraction system

2.3 Method of Production of Very Low Voltage Electric Current

Electric current is produced according to a physical principle based on thermoelectricity.

Indeed, it consists in the recovery (the valuation) of the losses by Joule effect emitted in the system (case of our system) upstream during the combustion of its product, the gas.

The purpose of this manipulation and the production of this prototype is to be able to show that the heat from the various machines or any other heat - generating system can be captured and transformed into another source of energy; electricity for example or even heating systems. Actual applications of such a system can be in vehicle exhaust systems, where combustion vapors can be captured, transformed into electricity and stored for various uses. The same system in larger proportions could be used in the chimneys of large processing plants, large catering kitchens and on a small scale in households.
To do this, we will carry out the different steps:

1) A 3D design and simulation of the different parts of the pilot system

Given the fact that our system will be subjected to a temperature above 70°C, it will therefore be necessary to cool the system as much as possible to keep it within its operating range.
The use of radiators and fans will be required to accomplish this function.
The 3D simulation will therefore aim to show the diffusion of heat in the system and the efficiency of the components according to the parameters that will be applied to them during the simulation. This will therefore make it possible to make a choice on the type of component (radiator, fan) to be used for a quality result.

2) A MATLAB simulation

This application in MATLAB will make it possible to represent in an experimental way, the electronic circuit of our pilot system. In a more detailed way, it allows us to see the resultants in current, in tension and in power of our system when it is subjected to an input temperature whose value we will choose. This observation (graph) will be done on a virtual oscilloscope in SIMULINK.

The purpose of this simulation will give us an idea on the choice of the Thermoelectric Generator according to the end use and the objectives.

3) The physical assembly of the prototype

The steps for making the prototype are as follows:

a) Prepare the basic components: radiators, fans, thermoelectric generators
b) Mount the above components as follows:
   - Thoroughly clean the surfaces of the radiators beforehand
   - Position the generator between the two radiators (the cold side against the large radiator and the hot side against the small radiator).

- Connect the modules together; connection can be made in two ways: series connection to increase voltage and current, and parallel connection to increase thermal efficiency.

c) Mount the fans on the large heatsink so that it can effectively cool the system.

d) Connect the fans to the modules (The positive (+) terminals all together and the negative (-) terminals all together)

e) Consume the gas resulting from the synthesis of biodiesel and position the flame below the small radiators so as to supply them thermally.

3. Results

Synthesis of biodiesel from used edible oils

In this part, two types of studies were carried out. Preliminary studies with catalysts (NaOH and KOH) at various concentrations and reaction times as well as a behavioral and comparative study of the biodiesel produced with conventional diesel based on physico - chemical parameters. In this series of experiments, the alcohol/oil molar ratio is 6: 1

Preliminary studies

In this study, the experiments were exclusively carried out with NaOH and KOH basic catalysts and with waste palm oil. Subsequently, there was variation in KOH concentration only with the aforementioned oil for the experiments. Alcohol is an essential parameter during the transesterification reaction and must be dosed at a value proportional to the mass of oil to be trans esterified. It was done according to the following equation:

Equation1: calculation of the mass of alcohol required

$$\frac{massede\ l'huile}{masseMolairede\ \ l'huile} = \frac{xmassedem\ \ éthanol}{6(32{,}04)}$$

For our experiment a mass of alcohol of 42.72 g was used for a ratio of 6: 1

3.1 Experiments performed with NaOH and KOH

Table 2: Biodiesel production results according to the type of catalyst

	NaOH			KOH		
	Gl (g)	BD (g)	η (%)	Gl (g)	BD (g)	η (%)
Webbed 200 (g)	66	134	67	40	160	80

It appears from these results that the reaction with sodium hydroxide (NaOH) produces more glycerin than does the reaction using potash (KOH). In addition, the glycerin due to potash is almost constant at a catalyst dosage of 1% and at 60 min of stirring. That is an average proportion of glycerin of 33% of the mass of the sample for the NaOH and 20% of glycerin for the KOH.

3.1.1 Experiments carried out by varying the concentration of KOH

The table below summarizes the data for the various yields as a function of the variation in catalyst concentration.

Table 3: Results of biodiesel production by varying the concentration of KOH catalyst

	Concentration KOH: 0.5%			KOH concentration: 1%			Concentration KOH: 1.5%			Concentration KOH: 2%		
	Gl (g)	BD (g)	η (%)	Gl (g)	BD (g)	η (%)	Gl (g)	BD (g)	η (%)	Gl (g)	BD (g)	η (%)
Webbed 200 (g)	23	58	29	40	160	80	32.44	167.56	83.78	20.44	179.56	89.78

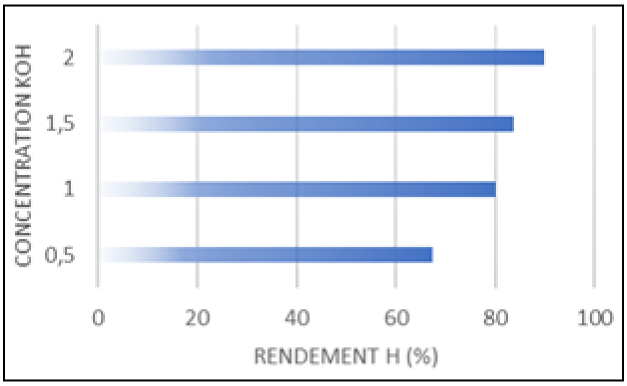

Figure 2: Evolution of the yield according to the concentration

By varying the concentration of the catalyst in the used food oil, the maximum yield (89.78%) is obtained experimentally with a KOH concentration of 2% of the mass of vegetable oil.

3.2 Behavioural study: modelling

3.2.1 Results of samples taken at reaction times

The table below contains the mass values of biodiesel and glycerin as well as the yields of the various transesterification reactions as a function of time.

Table 4: Results of samples taken at the pilot at reaction times

Samples	Duration of stirring	Sample mass (g)	Gl (g)	BD (g)	η (%)
E30	30	200	37	139.44	69.72
E60	60	200	30.2	144.16	72.08
E90	90	200	25.7	156.06	78.03
E120	120	200	20.44	179.56	89.78
E240	240	200	20.44	179.56	89.78

According to the series of experiments carried out above, it is found that, depending on the various results, several factors are to be considered during the transesterification reaction: the alcohol/oil molar ratio, mass of the catalyst. But the time factor is a precious element for obtaining better performance. It is found that the longer the stirring time, the better yield is obtained; this being after 120 minutes of stirring.

The graph below is representative of the curve of the change in yield as a function of time.

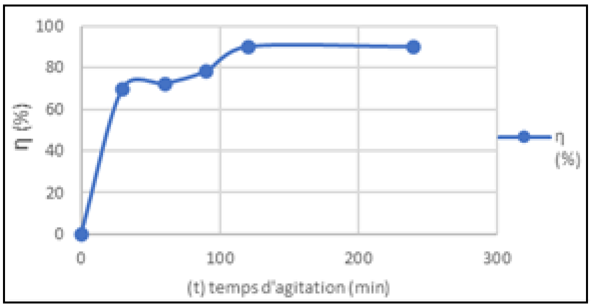

Figure3: Evolution of η (%) as a function of (t)

On closer observation, after 240 min the yield is similar to that of 120 min which leads to a conclusion according to our manipulation, that the best yield for a complete transesterification reaction with a molar ratio of 6: 1, is obtained. from 120 min of agitation.

3.2.2 Physico - chemical parameters of the biodiesel samples analyzed

Table 5 summarizes the results obtained from the analyzes for the different physico - chemical parameters of biodiesel in comparison with conventional diesel.

Table 5: Parameters of the samples analysed and compared to those of diesel

Samples	Density at 15°C (g/cm3)	Viscosity at 38.2°C (mm2/s)	Cloud Point (°C)	Pour point (°C)	cetane number	PCI (kcal/kg)	PCS (kcal/kg)
E30	0.890	4.28	8	6	55.1		
E60	0.886	3.98	8	6	-		
E90	0.882	3.92	7	6	-	9865	10505
E120	0.883	3.91	7	5	-		
E240	0.883	3.91	7	5	54.8		
diesel	Min 0.820 Max 0.890	Min 1.6 Max 5.9	Max +5	-	Mini 45	9088.99	10399.99

3.3 Production of electric current TBT

3.3.1 Prototype simulation in MATLAB_SIMULINK

The simulation of the prototype in Matlab aimed to understand the operation of the TEG thermoelectric generator in a real environment, according to two variable parameters: the ambient temperature (θ: that of the operating environment) and the temperature difference (ΔT) applied to the faces of the thermoelectric module. Taking these input parameters into account allowed us to obtain new output parameters, therefore: voltage (U), current intensity (I), power (W) and the Seebeck effect (α).

Figures 4 and 5 represent the assembly diagrams of the prototype in Simulink.

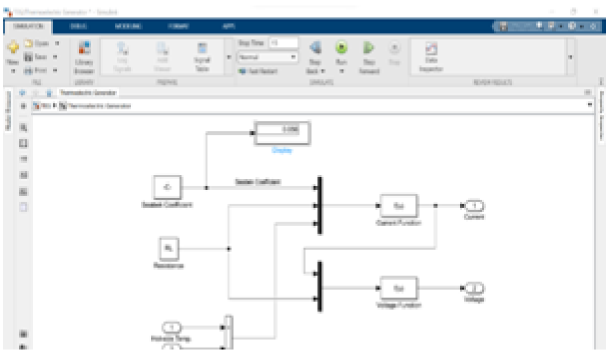

Figure 4: Thermoelectric module mounting circuit connected to a multimeter and a thermometer

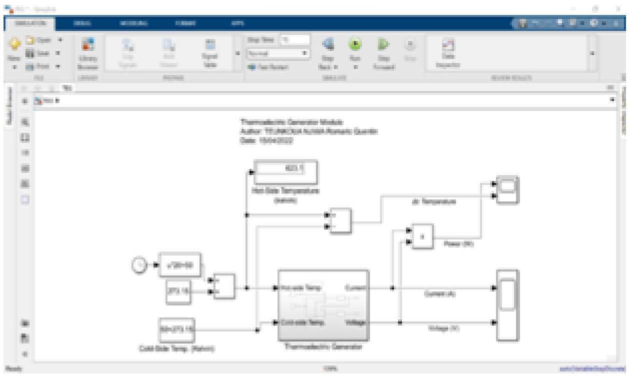

Figure 5: Thermoelectric generator mounting circuit

A heat source is applied to the thermoelectric generator in an environment taken at θ=25°C. the assembly associated with an oscilloscope and a themometer allows us to temporally control the output parameters of the TEGs (U, I, W, R, α) according to the temperature difference ΔT which must be maintained at 50°C.

The simulation model is parameterized so that the user can modify the input data in a very simple way. To change the input parameters, just change the values inside the source code responsible for controlling the TEG module. Due to the parameterization of the model, it is not necessary to search for values every time we want to modify them. When we modify the values of variables in the source code, they are instantly passed to the correct blocks in the simulation model. Figure 6 below shows us the changes in temperature (ΔT) as a function of power (W) and time (t). according to the evolution over time, an increase in the power delivered by the modules is observed up to a threshold of 25W at t=10 min and at ΔT= 138°C.

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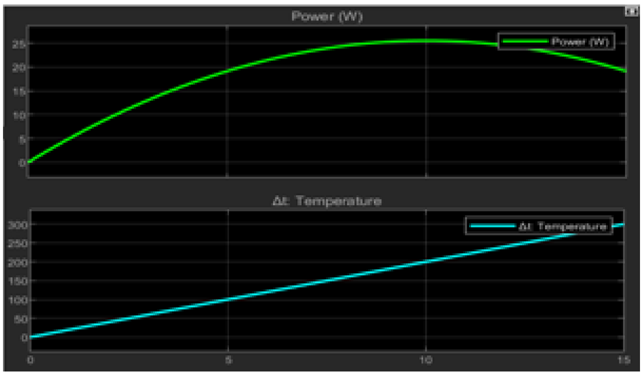

Figure 6: Changes in temperature (ΔT) as a function of power (W) and time (t)

At [10<t<∞] min, a decrease in the power curve (W) is observed, because the module no longer produces anything. This drop in productivity is marked by the fact that there is no longer any temperature difference between the different faces of the module and the Seebeck effect is canceled (α=0). the hot temperature has taken over the cold side of the module: it is overheating.

Figure 7 shows the time evolution of the intensity of the current and the voltage when the TEG module is subjected to a variation in temperature ΔT.

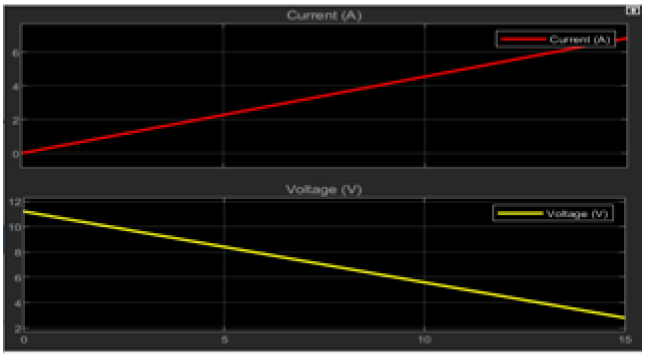

Figure 7: Temporal evolution of current and voltage intensity as a function of ΔT

According to the results, we obtain at t= 9 min and at ΔT= 50°C: a current I= 4.5 A and a voltage U= 5.6 Volts.

3.4 Experimentation on prototype

Table 6 is a summary of the data collected during the operation of the thermoelectric generator (TEG) after a repetition of 5 trials. The green area is where you begin to get considerable voltage and amperage for intended uses.

Table 6: Summary of the data collected during the operation of the thermoelectric generator (TEG) after a repetition of 5 tests

ΔT	U	I	P	S	RL	Icc
25	0	0	0.00	0	0.00	0.00
28	0.5	0.21	0.11	0.04	2.38	0.42
30	0.9	0.33	0.30	0.06	2.73	0.66
34	1.2	1.01	1.21	0.07	1.19	2.02
36.8	1.7	1.3	2.21	0.09	1.31	2.60
38.1	2	1.76	3.52	0.10	1.14	3.52
40	2.4	1.97	4.73	0.12	1.22	3.94
41.4	2.9	2.2	6.38	0.14	1.32	4.40
42.5	3.2	2.4	7.68	0.15	1.33	4.80
43.8	3.7	2.8	10.36	0.17	1.32	5.60
44.6	4	3.4	13.60	0.18	1.18	6.80
46.2	4.5	3.7	16.65	0.19	1.22	7.40
47.3	**4.9**	**4**	**19.60**	**0.21**	**1.23**	**8.00**
49	**5.1**	**4.2**	**21.42**	**0.21**	**1.21**	**8.40**
49.7	**5.3**	**4.43**	**23.48**	**0.21**	**1.20**	**8.86**
50	**5.6**	**4.50**	**25.20**	**0.22**	**1.24**	**9.00**

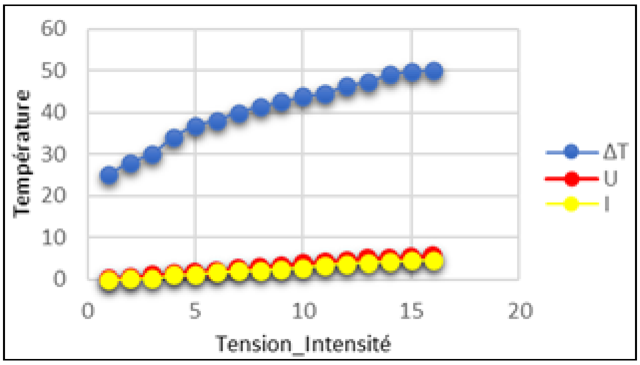

Figure 8: The temporal evolution of parameters obtained at the output of the TEG in operating mode

the graph of figure 8 shows us the temporal evolution of parameters obtained at the output of the TEG in operating mode. We note as during the simulation a growth of the curves; but at a time t, it begins to decrease, this is the overload point where the temperature difference between the two faces of the module disappears. Another analysis is carried out on the irregularity of the curves which is more marked on that of ΔT; due to the variations of the heat flow influenced by the winds of the environment where the system is located.

3.4.1 Boosting of TEG output parameters

Since the influences of air currents have an impact on the productivity of the TEG, we have equipped the device with a Voltage Boost circuit.

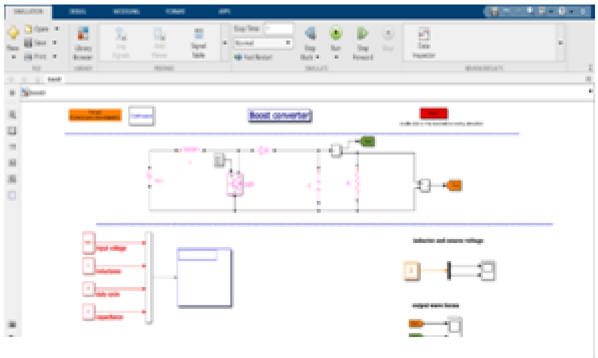

Figure 9: TEG Boosting Circuit

the circuit (figure 9) is that of the operation of the booster circuit of the thermoelectric system. The purpose of this circuit is to raise the voltages obtained at the terminals of the various modules for device uses requiring a voltage greater than 5 volts. In our case the Boosting is carried out up to 48 volts.

3.5 3D modeling of the thermoelectric generator

Figure 10: 3D modeling of the thermoelectric generator

Figure 10 Above shows the 3D model of our construction system (thermoelectric generator).
For efficiency and effectiveness of operation, the system has been composed of 4 radiators (two for cooling and two for heating the modules) located on either side of the modules. Since the system is a heat receiver, its prolonged operation will cause overall overheating; and the generator will no longer produce electrical energy, as an almost constant temperature difference must be created for efficient production.

To do this, forced convection (fans) and conduction (chilled water block) control systems have been used as a constructive solution to ensure the proper functioning of the generator.

3.5.1Simulation of radiators and fans

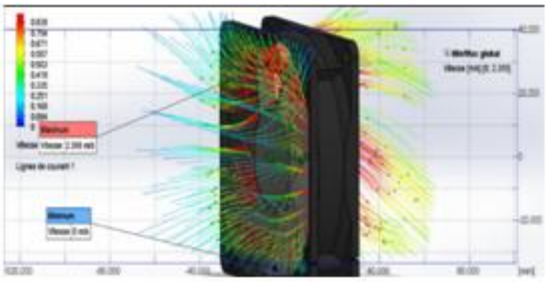

Figure 11: Simulation of the TEG ventilation system

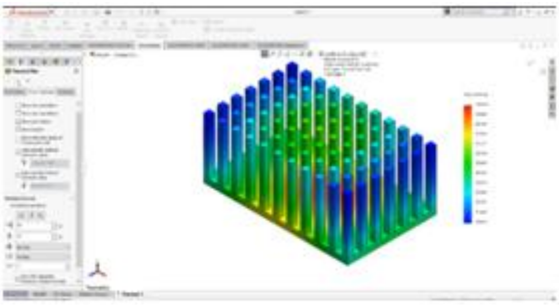

Figure 12: Simulation of TEG Radiators

The simulations of the cooling system in the SOLIDWORKS software led us to the following results and observations:

Figures 11 and 12 illustrate the thermal simulations of the various heat exchange components.

Figure 11 is that of the simulation of fans subjected to an overall min/max speed [m/s] [0; 2.335]. This maximum speed is the speed at which the fans manage to effectively cool the radiators being coupled to cooling radiators and a water block of temperature [0; θe; 11] [°C].

Figure 12 is that of the simulation of heat conduction radiators; interfacing between the heat source and the hot face of the thermoelectric module. It shows how the heat flow is distributed from the heatsink to the module.

A concentration of heat is observed in the center of the flat face of the radiator (red color); this symbolizes the resident temperature on the hot face of the module which will allow the movement of electrons between the semiconductors to produce electric current.

4. Discussion

4.1 Production of Biodiesel from HAU

4.1.1 Types of catalysts: NaOH and KOH

According to the literature, NaOH and KOH catalysts are the most commonly used basic catalysts in homogeneous catalysis due to their better performance. In our preliminary study, we used waste palm oil. The best biodiesel yield was obtained with 200g palm oil catalyzed with KOH with a value of 89.82% against 77.43% with NaOH for a reaction time of 120 min and 240 min and a dosage in 2% catalysis. This is confirmed by the literature (Oguntola, Waheed, & Jekayinfa, 2007). At different concentrations, KOH always performed better than NaOH.

Additionally, NaOH and KOH catalysts contain sodium and potassium atoms, which are highly reactive alkaline chemical elements. This also gives these catalysts great reactivity. It should be noted that potassium dissolves more easily in alcohol during the preparation of the catalyst (melting temperature 63°C) than sodium, whose melting temperature is 98°C. Moreover, their densities, boiling points and molar atomic masses are not identical. All these physico - chemical differences could justify the better behavior of KOH compared to NaOH.

4.1.2 Change in KOH concentration

By varying the KOH concentration from 0.5 to 2%, yields of between 25 and 89.78% are obtained. The yields obtained at a concentration of 0.5% are much lower than those found in the literature(Oguntola, Waheed, & Jekayinfa, 2007). This is explained by the loss of biodiesel during washing. It should be noted that the production of glycerol at this concentration is the lowest of the others.

On the other hand, our yields obtained at 1% confirm those of the literature since the optimal yield is obtained at this concentration. Which is the case at almost 90% of production here.

At 2% concentration the yield ratios are within the normal range. We find that more acidic oils work better here than unsaturated or weakly saturated oils. This is because some oils require a little more KOH to first neutralize free fatty acids before using the rest to catalyze reactions.

4.1.3 Analyzes of the physico - chemical parameters of biodiesel

It can be seen that the E120 sample gives a better yield of89.78%. On the other hand, the lowest value is 69.72% for the E30 sample. The yield in 120 minutes is better because the reaction will be complete in 90 minutes. According to the study by Nigerian researchers(Oguntola, Waheed, & Jekayinfa, 2007), the yield becomes constant from 90 minutes to the end of the reaction (for example 120 minutes). In addition, the yields of the E30 and E60 samples are less good than that of E90. The biodiesel produced in 30 and 60 minutes contains a certain proportion of vegetable oil which is not yet entirely present. This is justified by its viscosity according to SONABHY analyzes in the literature of Abiona(LOMPO, 2008).

Among the parameters analyzed, we note a constancy of the values for all the samples, with the exception of the viscosity which varies. The variation in viscosity is clear for the instants 30 and 60 minutes, but from 90 to 120 minutes it can be considered as constant. From 90 to 120 minutes, the samples have almost identical properties. By comparing our samples to SONABHY specifications for diesel fuels, we found the range of density and viscosity values acceptable in this case.

4.2 Production of Electric current TBT

According to the literature, thermoelectric modules are devices in which, subject to a temperature difference, a voltage difference is obtained. (M. Ohta & S. Hirai, 2007).

During the simulation of the TEG system in MATLAB Simulink, we observe an effective production of electric current by the thermoelectric modules subjected to an input temperature value and an output voltage value. At ΔT = 50°C, a parallel system voltage of 5.6 Volts is obtained; knowing that a module produces approximately 2.5 Volts; These results agree with those of the literature. (Boudemagh, 2010).

At [10<t<∞] min, we observe a drop in voltage production as shown by the simulation graph in figure 6; this marked by the overheating of the thermoelectric modules. The results of this simulation are similar to those obtained during the experiment on the real prototype as shown in the graph in figure 8.

A constructive Solution has therefore been introduced to the system; This being cooling equipment to maintain ΔT at 50°C, allowing us to have a voltage of 5V as in the literature. But during the operation of the system, we were able to observe a variation in the heat flux emitted by the source leading to a drop in production. To remedy this, we added a Voltage Boost device to raise the voltage when ΔT is falling, allowing us to reach 48 volts.

5. Conclusion

We are interested in this research work in the design and the realization of a pilot system of production of Gas and Electric Current TBT by the Biodiesel resulting from the valorization of used edible oils.

After contextualizing and justifying the global situation, more specifically that of Third World countries such as those in Africa, faced with the energy deficit and the use of renewable energies as alternatives to conventional energies, we have highlighted the different motivations that have enabled us to design and realizepilot system extraction of gas and production of a TBT electric current by Biodiesel resulting from the recovery of used cooking oils. A collection approach has been developed for a considerable acquisition of raw materials (used edible oils) from potential producers (agri - food industries, restaurants and households), thus limiting their discharges into the environment.

By a chemical process known as the Transesterification reaction, we have transformed the collected oils into Biodiesel; this in the presence of catalyst (NaOH and KOH) and an alcohol (Methanol) for a period of 120 min where we were able to achieve the best result 89.82% with the KOH catalyst.

Finally, a numerical simulation in MATLAB SIMULINK and SOLIDWORKS of our Thermoelectric Generator allowed us to operate the system virtually under real conditions of use, according to two variable parameters: the ambient temperature (θ: that of the operating environment) and the temperature difference (ΔT) applied to the faces of the thermoelectric module; in order to better understand the physical realization of the pilot system.

6. Future Scope

- As perspectives for future work, the main points for improvement will be:
- The endowment of the Thermoelectric generator with an automatic control system / module with Human - Machine - Human interfacing;
- The implementation of a real - time parameter acquisition system from the machine components according to industry 4.0;
- Boosting the production of electric current at a voltage of 220 volts;
- the aesthetic improvement of the pilot system itself;
- Gas bottling and marketing in different localities and in the long term internationally.

Conflict of interest

The authors declare that they have no conflict of' interest.

References

[1] Akon Lighting Africa. (2018, April 25). SUSTAINABLE ENERGIES FOR THE PERMANENT ELECTRIFICATION OF AFRICA. Media earth, 4.0. Retrieved from https: //www.mediaterre. org/actu, 20180425075743, 15. html

[2] Boudemagh, D. (2010). Synthesis and Study of Thermoelectric Materials of the System. University Joseph - Fourier - Grenoble I, Physics.

[3] Copinschi, P. (2010). Oil, what future? Retrieved from https: //www.cairn. info/le - petrole - quel - avenir - - 9782804113148 - page - 75. htm?contenu=resume
[4] The official oil price. (2022, January). price per barrel. Retrieved from https: //prixdubaril. com
[5] The price of a barrel of oil exceeds 146 dollars. (2008, July 3). the stitch log. Retrieved from http: //www.lepoint. fr/actualites - monde/le - prix - du - baril - de - petrole - depasse - les146 - dollars/924/0/257547.
[6] LOMPO, J. (2008). Analysis and dimensioning of fuel production processes. Thesis of the end of studies of the engineering cycle of the 2ie.
[7] M. Ohta, & S. Hirai. (2007). Synthesis and thermoelectric properties of ternary rare - earth sulphides LnGdS3 and LnCuS2 (Ln: Nd, and Sm). The 26th International Conference on Thermoelectrics: ICT Symposium Proceedings. Jeju Island, South Korea.
[8] Oguntola, A., Waheed, A., & Jekayinfa, SO (2007, Dec). Optimal Transesterification Duration for Biodiesel Production from Nigerian Palm Kernel Oil. The agricultural Engineering International: The CIGR e - journal 9.
[9] Planet. (2021, March 17). Natural resources in a state of depletion. Retrieved on Jan 24, 2022, from https: //www.save4planet. com/ecologie/249/epuisement - ressources - naturelles
[10] planetscope. (2018). Global CO2 emissions into the atmosphere. Retrieved from https: //www.planetoscope. com/co2/261 - . html
[11] REFAAT. AA, ATTIA. NK, SIBAK. HA, SHELTAWY. ST, E., & ELDIWANI. GI (2008). Production optimization and quality assessment of biodiesel from waste vegetable oil. Int. J. About. Science. Tech, 5 (1), 72 - 82.
[12] Sylvain. (2019, June 8). From collection to recovery of used cooking oil: an ecological approach. The Oil Shack. Retrieved from https: //www.labaraqueahuile. fr/de - collecte - a - valorisation - de - lhuile - de - cuisson - usagee - demarche - ecologique/
[13] Tint, KT, & Mya, OM (nd). Production of Biodiesel from Jatropha Oil (Jatropha curcas) in Pilot Plant.

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