Solar algae dryer

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***Abstract*—**The algae production is a growing business because of its many useful compounds. In order to collect these compounds algae must first be dried. Nowadays the solutions used for drying are too expensive and uses too much energy. This paper presents our solution for this problem, the technologies we used to build our Solar algae dryer, and what benefits it has to current solutions. The solar dryer is built to work as a distiller and also uses solar power as an energy source. It is also built with a controlling process to be sure that compounds of the algae are not harmed.

***Keywords*—**Algae, Dryer, Energy-efficient, Solar power

I. INTRODUCTION

THE algae production and industry is a growing business and we want to be a part of it. Because of that we decided to design a solar algae dryer for the chemical departments lab at ISEP. The main requirement for this dryer was to dry the algae only with the use of solar power. This means that we did not think of any solution other than solar powered solutions. There were also other requirements such as, it had to be smaller than $1m^2$, the temperature couldn't exceed 50°C and it has to dry the algae to less than 10% humidity in one day. It is a very interesting field because algae production is becoming more and more popular, and to be able to extract antioxidants, omega 63 fatty acids, pigments, oils, starch, etc. from algae we need to find new ways of drying it.

We designed this dryer as a distiller, which means that we will dry the algae with direct solar radiation, that will warm up the algae and the water evaporates. We also use the solar radiation for our controlling process, which means we get the power to all controllers from a solar panel.

The paper is organized in six different sections. First we have State of the art that describes related products and technologies. Then Materials and methods describe what technologies we used in our project. After in project development we present the design of the product and the steps we did when we built it. Then we have the test chapter where we talk about the tests we made and the results from these tests. In the end we talk about future developments, what could be improved on the product in the future and after this a discussion and conclusion.

II. STATE OF THE ART

Related products

We are making our product for the lab in first hand and nowadays most of the labs working with algae use a centrifuge to dry them. Figure 1 shows a centrifuge often used in labs. But this method uses too much energy and is too expensive.

Figure 1. Typical lab centrifuge [1]

There are also some companies working with different algae production. The main competitor for our solar dryer is a company from The Netherlands called Algaelink [2]. They have also a product called solar dryer, but the difference between theirs and ours is that we are controlling the process and they are not. In this case we can guarantee that the compounds of the algae are not getting harmed during the drying process.

Figure 2. Solar dryer [2].

As shown in Figure 2, the solar dryer from Algaelink is a simple solution with a big “table” where they dry the algae.

III. Methods and Technologies

For our project we had to use different technologies to make it work properly. This chapter gives an overview of the technologies we used.

1. UV-resistant Tank
2. Temperature sensor
3. Ultrasound sensor
4. Stepper motor
5. Arduino Uno
6. Solar panel and battery

UV-resistant Tank

Ultraviolet radiation is a part of the light invisible to our eyes, a portion of electromagnetic spectrum in between 400-100 nm. It has different components for example UVA, UVB and UVC. The most common one is the UVA radiation needed by humans for the synthesis of vitamin D, UVB radiation, on the other hand, is considered the most harmful.
In order to not harm the algae with ultraviolet radiation we had to build the tank of a material that keeps the UV-radiation outside. For this we are using Plexiglas that is 99% UV-resistant [3].

Temperature sensor

We also needed to control the temperature of the water so it does not exceed 50°C and harm the algae. For this case we installed a waterproof temperature sensor that will measure the temperature of the water and be connected to the Arduino. If the temperature rises over 50°C it is programmed to stop the drying process.

Ultrasound sensor

For the end of the process we need a sensor to know when it is finished. When we have less than 10% left of the solution it is dry enough and the process should stop. The ultrasound sensor is attached to the side of the tank. It generates high frequency sound waves and evaluates the echo that is received back by the sensor. The sensor calculates the time interval between sending and receiving the echo signal to determine the distance to the water surface [4].

Stepper motor

A stepper motor is a brushless DC electric motor that divides a full rotation into a number of equal steps. The motor’s position can then be commanded to move and hold at one of these steps without any feedback sensor. The stepper motor is mounted on the top of the tank and is used for the stopping process. It is connected to a blind and it rotates and closes the blind if the temperature should decrease inside the tank or if the process is ready [5].

Arduino Uno

For all these sensors and components we also need a controller. We are using an Arduino Uno micro controller that is connected to all sensors and controls the process. Arduino is a single-board microcontroller designed to make the process of using electronics in projects more accessible. It is an open source prototyping platform based on flexible, easy-to-use hardware and software [6].

Solar panel and battery

The idea for the project was all the time to use solar power. To fulfill this requirement we are using a solar panel to supply power to all electrical devices. The solar panel is 15 W and will be mounted on the tank. To be sure that we have power all the time, even if the sun is not shining, we also need to have a battery. The solar panel will be connected to the battery and charge it, we are using a 12 V 2.3 Ah battery.

We chose all these technologies because they were all suitable for our project and we already had some of them in school.

IV. PROJECT DEVELOPMENT

In this chapter we present the design of the product and the steps we took when we planned it and built it.

In Table 1 the main parts from the material list are presented and figure 3 shows the box world of the product.
The box world shows all components in the product and how they are connected to each other.

Table 1. Material list

Quantity	Description
1	Plexiglass (118x126 cm) 6 mm
1	Ultrasound water level controller
1	Waterproof temperature sensor DS18B20
3	Fan 12 V DC
1	Solar panel 15 W
3	LED-diodes
1	Battery 12 V
1	Micro-controller Arduino uno
1	Stepper motor Astrosyn Y129
1	Blinds 60x130 cm2
3	Valve 13 mm
4	Wheels

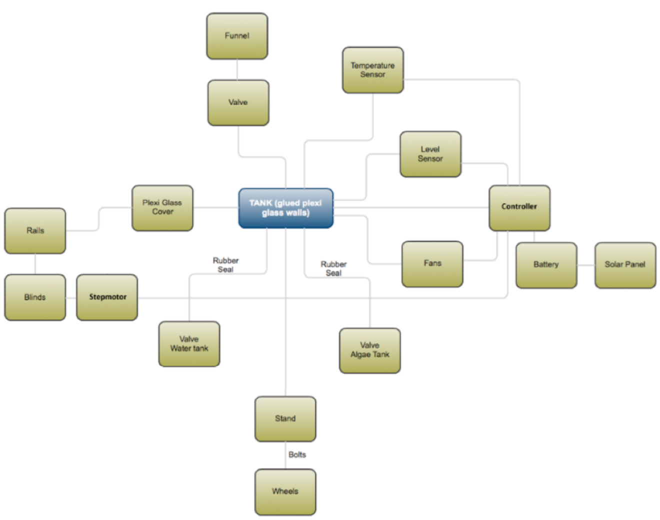

Figure 3. Box world

The 'main' part of our project, the tank, was designed by ourselves. In the very beginning we brainstormed and started to come up with different ideas how the tank should look like. It had to fit 5 l of solution and when the water evaporates it needs to go somewhere, this was the most important parts to include in our design. The illustration of the actual tank is shown in Figure 4.

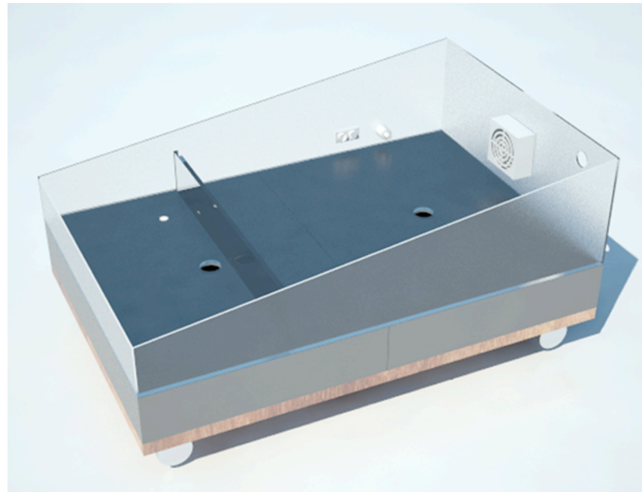

Figure 4. 3D model of tank

After we were ready with our tank model we needed to think of how to meet all the requirements. For this we made a flowchart to understand how all the components needed to work and communicate with each other. The flowchart is presented in Figure 5.

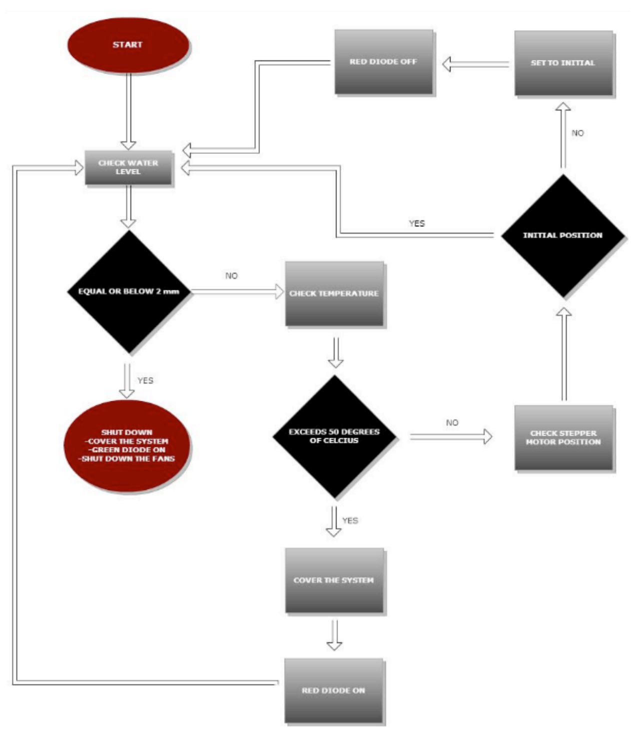

Figure 5. Flowchart

In the flowchart, all different decisions that need to be made to control the process are presented. It starts with checking the water level, if it is ready or not, and make decisions according to the result. Then it checks if the temperature is okay and if the blinds are open or not.

We also needed to make an electrical chart to know how to connect every electrical device. The electrical chart is presented in Figure 6 and shows all the connections that we need to have in order to control the process.

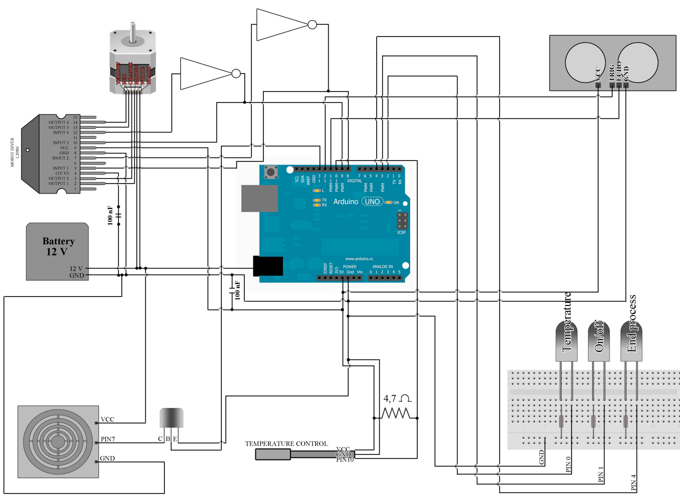

Figure 6. Electrical chart

V. TESTS

In this chapter we present what tests had to be made during the development of the product and what tests have to be made in the end to see if it is working correctly.

We spend a lot of time on testing if we could attract the algae with a different charge. At first we made a charging test in INEB laboratory to see what kind of charge the algae had. This was done by a method called Laser Doppler Electrophoresis. This test showed us that the algae were negatively charged and now we had to test if we could attract them with a positive charge. For this we built a capacitor, which are two charged plates, one positive and one negative. And between the plates and the algae there is a capacitor, in this test we used a small plastic box. We measured the density of the algae on the sides of the box to see if the algae was attracted and moved to one side. A setup from the test can be seen in Figure 7.

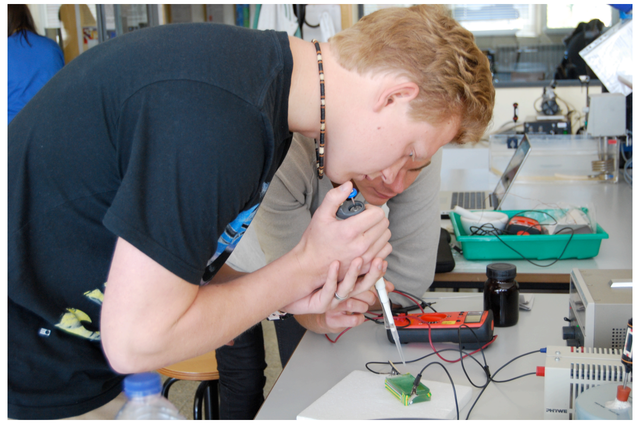

Figure 7. Charging test

We got positive results form this test but we did not have enough time to include the technology in our prototype. This will be a technology to work with in future developments.

The tests that our product needs to fulfill in the last testing phase are following:

1. In order to know if the temperature sensor works we have to put water inside the tank with a temperature over 50°C, in this case the temperature sensor needs to give a signal and the stepper motor should close the blinds.
2. When need to put 5 l water inside and slowly empty the tank, when the water level drops to 2mm (only 0,5 l left) the ultra sound sensor should give a signal and the blinds closes and green diode turns on.

These are the main tests that our solar dryer needs to fulfill when it is ready.

VI. FUTURE DEVELOPMENT

What future development is concerned, the main thing to focus on is the results from our charging test. It should be made further investigation in this area and how it could be implemented in our solar dryer. For example the drying process could be made much faster if we could attract the algae to the bottom of the tank, and in that case remove half of the water directly from the beginning.

For the future it could also be interesting to think about a process where it automatically removes the algae from the tank when the process is ready. This could be made maybe by an electrical pump that sucks out the algae from the tank.

Another idea to think about in future developments is how to combine the solar dryer with a water recovery system. The water obtained during the distilling process could be recovered and reused afterwards.

It could also be investigated how to connect the dryer to algae growing farms.

VII. Conclusion

When looking back at the past four months that we dedicated to develop our project there is some things that come to our minds. From the beginning our thoughts were to develop a product with low power consumption that would work and replace the centrifuge that our client is using now. That was the expected result from the beginning. After we had some troubles with the ordering and delivery of the materials and because of that got delayed in our process we can state that we did not fulfill all of our expected results. Also the electronic devices and connections caused us some problems because we did not have any experience in that field. Throughout the process we learned that a better planning and proper deadlines for ourselves would have helped us finish in time.

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References

[1] Wikipedia (2013, Jun.) www.en.wikipedia.org (Online) http://www.en.wikipedia.org/wiki/Centrifuge

[2] Algaelink (2013, Jun) www.algaelink.com (Online) www.algaelink.com/joomla/index.php?option=com_content&view=article&id=8&Itemid=10

[3] Gary Zeman (2013, Mar) www.hps.org (Online) http://hps.org/hpspublications/articles/uv.html

[4] Robot electronics (2013, Mar) www.robot-electronics.co.uk (Online)

[5] Astrosyn (2013, Mar) http://www.uk.farnell.com/astrosyn/129/stepper-motor-1-8deg-12v/dp/9598642 (Online)

[6] Arduino (2013, Mar) www.Arduino.cc (Online) http://www.arduino.cc/en/Main/arduinoBoardUno