HUMIDIFIER WITH A WEB INTERFACE CONTROL

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1. Abstract

In the text we will show how to make a humidifier with a web interface control. The goal of our project is to keep under full control the humidity level of a 80 m³ server room. We will go through, step by step, from choosing the type of humidifier,it control, and the web interface we are planning to buildup.

2. Glossary

Arduino UNO -The Arduino Uno is a microcontroller board based on the ATmega328 .
It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. [13],[19].

Ethrnet card- a kind of network adapter. It supports the Ethernet standard for high-speed network connections via cables. [32]

ICSP - In Circuit Serial Programming, a method of directly programming form microcontrollers.[31]

Java - Is a programming language originally developed by James Gosling at Sun Microsystems (which is now a subsidiary of Oracle Corporation) and released in 1995 as a core component of Sun Microsystems' Java platform.

Marketing plan - Plan sales, marketing (Marketing Plan) is a written document that details the actions necessary to achieve a specific objective of the market.

µC, MCU – microcontroller - is a small and low-cost computer built for the purpose of dealing with specific tasks. [10]

PLC - Programmable Logic Controller – digital device, used to automate electromechanical processes. [9]

PWM outputs - Pulse-width modulation, a commonly used technique for controlling power to inertial electrical devices, made practical by modern electronic power switches. [30]

Relative humidity - The measurement of water vapor in the air and water vapor mixture. [33]

3. Introduction

This report describes how to build and implement a portable humidifier controlled via a web interface. This report also introduces to the reader different types of humidifiers shows which best suits our needs: possess the temperature sensors, water level sensors in the tank, how and which elements will be connected with the web interface.

This report is divided into 4 parts:

- introduction, where we present the problem, objectives and work plan;
- state of the art, where distinct types of humidifiers will be introduced;
- project development, where the process of building the humidifier will be presented;
- conclusions, where problems and achievement will be discussed;

Our main objective is to build a humidifier with a web interface for a data center of 80 m^3. The relative humidity which should be maintained -with the use of the humidifier- is between 40 % and 70 % (± 5%). It should be autonomous for two days and it should posses water and humidity alarms. Moreover, a good distribution of water vapor is expected. The humidifier should be compliant with the EU Directives 2006/42/CE 2006-05-17 and 2006/95/CE 2006-12-12.

We analyzed data from the Data Center – the temperature and humidity - and we found out that the relative humidity drops below 40%, (the lowest we observed was 36%). This problem escalates during summer when the temperature outside is very high. That is the reason why we need to install an humidifier.

In order to make our work more efficient, we distributed tasks between all members of the team. To be sure that all tasks will be completed on time, a Gantt chart was created. Marta and Ivan were responsible for the humidifier and composite box, while David and Peter were responsible for the controlling system and creating the web interface.

4. State of the art

Why humidifying a data center is so important? If the relative humidity drops below 40%, the excess of static electricity may cause sparks which can damage servers and IT equipment. A high level of humidity is also inconvenient for electrical machines. Both situations may cause server downtime and may lead to serious equipment damage and, consequently to large cost.

4.1. Types of humidifiers

There are a few types of humidifiers which we considered during our search for a good solution to our problem. They are presented below.

4.1.1. Evaporative Humidifiers

In evaporative humidifiers mist is produced by blowing water through a wick filter with the use of a fan. Hot air goes through a wet filter causing the increase of humidity and decrease of temperature. The mineral dust and bacteria get trapped on the filter before the water evaporates into the air. The advantage of this kind of humidifier is that the wick filter ensures a pure and clean mineral-free moisture output. Moreover, fans can be powerful enough to cover large areas with a single humidifier. Power consumption is very low. This solution also has also some disadvantages: fans make more noise than other types of

humidifiers (noise level depends on fan speed), and bacteria and mold can grow on the wick filter very easily. However, the latter problem may be reduced by using a bacteria treatment water additive, but still most wick filters need to be replaced approximately every 2 months. [1], [2], [3]

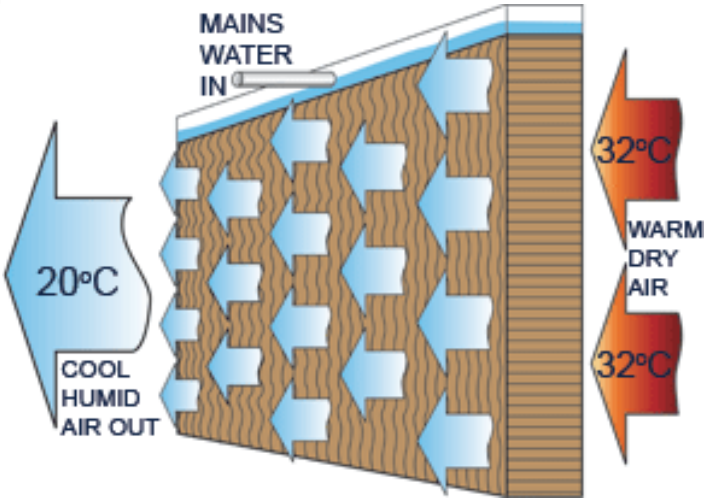

Fig.1. Evaporative humidifier.[5]

4.1.2. Impeller Humidifiers

In impeller humidifiers a fan blows water through a diffuser and, as a result, it produces fine droplets. In contrast to evaporative humidifiers there is no filter, so there is no need to replace it, reducing the cost of maintenance. Moreover, it is very quiet while working. Additionally,these humidifiers have low power consumption and are cheaper than evaporative humidifiers. On the other hand, there is a risk that bacteria and minerals can spread in the air along with the mist, what may cause white dust. Its use is limited to small rooms. [1], [2], [3]

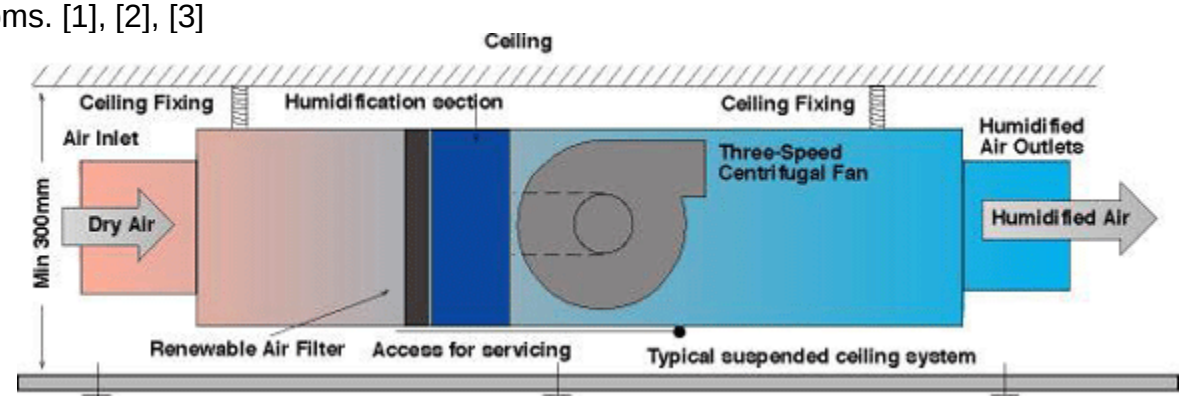

Fig. 2. Impeller humidifier. [4]

4.1.3. Ultrasonic Humidifiers

Ultrasonic humidifiers use high-frequency vibrations to dissipate water into the air. This method is the quietest of all. Additionally, the power consumption is very low (when using cool mist) and there is no need for replacing filters. However, it may occur white dust formation as in the case of the impeller type of humidifier. Like the previous methods, the

ultrasonic humidifiers are reserved for small rooms only. [1], [2], [3]

4.1.4. Warm Mist Humidifiers

These humidifiers heat the water and expel steam into the room. Water is heated and mixed with the air as a vapor. This method is very quiet and produces pure and clean mineral-free moisture output. Furthermore, there are no filters to replace. On the other hand, there is a higher power consumption (heating element uses more electricity than other types of humidifiers) and it is limited to small rooms only. [1], [2], [3]

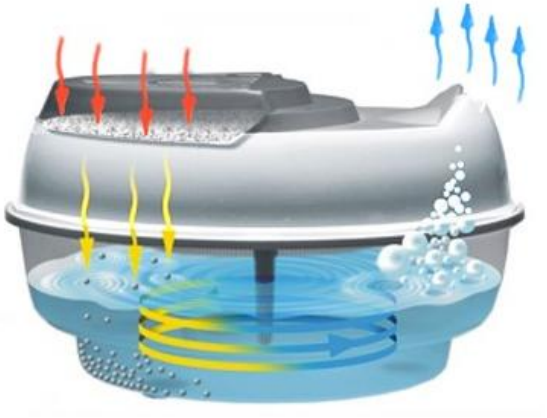

Fig. 3. Warm mist humidifier.[8]

4.1.5. Humidifier with an air compressor

The water is blown into the air through nozzles that mix high-pressure air with water. Due to the high-pressure air, the water is dispersed as water vapor trough the nozzle. This method is very effective and provides a good distribution. However, it is high energy consuming. Additionally, it is very expensive to build this type of humidifier.

4.2. Solutions for controlling

There are two basic ways to solve the control aspect. Our objective was to choose from these tools the best to realize the humidity-level control in a server room. The options are the following:

4.2.1. PLC

A PLC is a digital computer used for automation of electromechanical processes. [9] PLCs are used in many industries and machines. PLCs have standard inputs/outputs, and may include Ethernet connection. The most important feature of the PLC is their universal usability, but usually PLCs are used in industry. The main difference from other controllers is that PLCs are armored for severe conditions (such as dust, moisture, heat, cold) and have the facility for extensive input/output (I/O) arrangement allowing the PLC to connect

with sensors and actuators. PLCs read limit switches, analog process variables (such as temperature and pressure), and the positions of complex positioning systems.On the actuator side, PLCs operate electric motors, pneumatic or hydraulic cylinders, magnetic relays, solenoids or analog outputs. The input/output arrangements may be built into a simple PLC, or the PLC may have external I/O modules attached to a computer network that plugs into the PLC.

4.2.2. Microcontrollers :

A microcontroller is a device that can be used to control some process. It includes a processor core, memory, and programmable inputs/outputs integrated in a small card. [11] Microcontrollers are used to automatically control processes and devices. By reducing the size and cost compared to a dedicated design that uses a separate microprocessor, memory, and input/output devices, microcontrollers make it economical to digitally control devices and processes. The microcontroller can be programmed to perform several functions and, when equipped with an Ethernet card, provides standard web interface. These device µC-s have low energy consumption (mW or µW). Microcontrollers are more sensitive to the environment (chemical material, temperature, etc.) than PLCs.

4.2.3. Flowchart :

Control diagram

Humidifier system control

- HV: Humidity Value
- HLS 1,2,3 : Humidity Level Sensor
- HF Stand by: Humidifier Stand by
- WLS 1,2 : Water Level Sensor
- 1st WLA: 1st Water Level Alarm
- 2nd WLA: 2nd Water Level Alarm
- HL OK: Humidity Level is OK
- 1st HLLA: 1st Humidity Level LOW Alarm (Humidity level is under 45%)
- 2nd HLLA: 2nd Humidity Level LOW Alarm (Humidity level is under 40%)
- 1st HLHA: 1st Humidity Level HIGH Alarm (Humidity Level is above 55%)
- 2nd HLHA: 2nd Humidity Level HIGH Alarm (Humidity Level is above 70%)

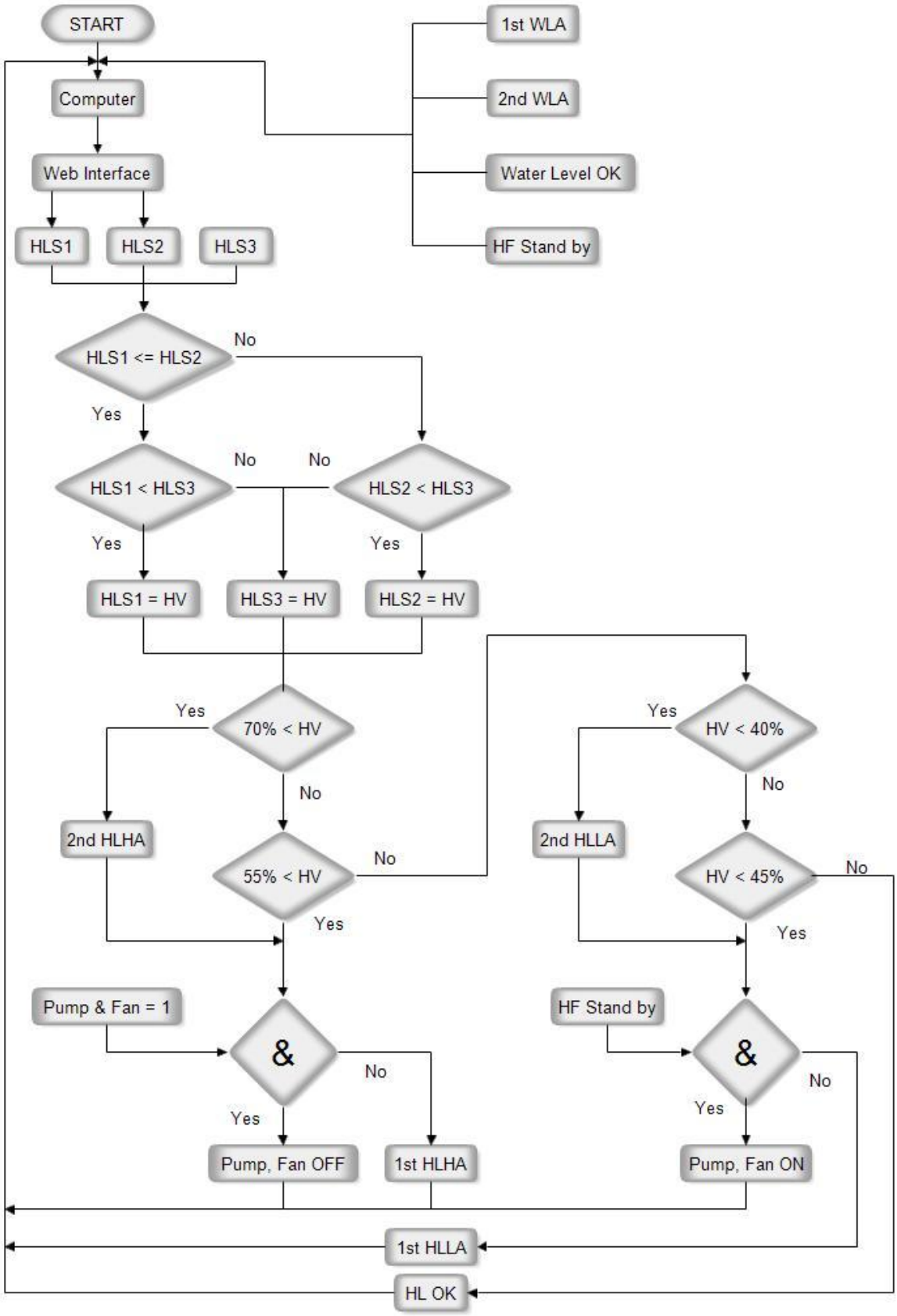

Fig , 4. Flowchart

4.3. Conclusions

In our project we made unformed choices based on the competitive analysis of the different possibilities. Finally, we decided in favor of an evaporative humidifier because it is very cheap to build as well as to maintain. Moreover, this method provides easy control and distribution of water vapor.
Due to the price, size and low energy consumption we selected a microcontroller for controlling. To make these decisions we used comparison tables with points, where 5 was considered as the best, while 1 was the worst mark.

Tab. 1. Table with points for each humidifier.

	Ultrasonic humidifier	Evaporative humidifier	Humidifier with the air compressor	Impeller humidifier
Cost	3	5	1	3
Maintenance cost	3	3	4	4
Consumption of energy	4	4	1	3
Complexity	3	5	1	3
Size	2	1	4	4
Efficiency	3	1	5	3
Control	4	4	5	2
Total	**22**	**23**	**21**	**22**

Tab. 2. Comparison between PLC and microcontrollers

	Microcontroller		PLC	
Cost	4		2	
Power Supply	12 V	3	230 V	3
Programming	3		4	
Inputs/outputs	5		5	
Ethernet	5		5	
Total	**20**		**19**	

5. Marketing Plan

5.1. Marketing Index

Situation Analysis

- Vision
- Target Audience
- Segmentation
- Needs and Requirements
- Competitors
- SWOT Analysis

Marketing Strategy

- Market Program
- Strategy To Be Competitive
- Goals

Marketing Mix

- Detailed Product Information
- Distribution & Logistics
- Price Strategies
- Promotional Strategy
- Monitoring and Marketing

Summary

5.2. Market Analysis

5.2.1. Vision

Due to the growing interest humidity level and its consequences, we propose an innovative humidifier that combines efficiency with simplicity. It is so important, because it is possible that if the relative humidity drops below 40%, excess of static electricity may cause sparks which can damage servers and IT equipment. Moreover, this is controlled by web interface and allows for 2 day of autonomy. It is also environmentally friendly because it consumes a lot of energy and it is compatible with EU directives. We want to provide humidifiers mainly for data centers in order to maintain proper humidity.

5.2.2. Our firm

Our firm want to break into the Portugal market like a new firm and get the first position in the next 3 years. We sell humidifiers for data centers, we plan the whole humidifier system according to specific requirements with additional services. Specific requirements for example controlling system and web interface etc…

5.2.3. Target audience

Primarily we offer solutions for humidifying data centers, but we also undertake other specific needs.

Data centers are found the following locations:

- Shopping malls
- Banks
- Universities
- Airports
- Government agencies
- Medium and large companies
- Hospitals
- Business center

5.2.4. Segmentation:

Our ideal customer would me a small data center, which is cares about the safety of its IT equipment, environment and looks for savings.

5.2.5. Needs and Requirements

Our customers do not need very sophisticated humidifying system. They look for something which do not cause excess of water in air, because it is much more dangerous than too low humidity. These companies look for information in the internet for example on online forums. They have limited amount of money.

5.2.6. Current competitors

Humidifier market is very large, complex and quite saturated, many companies are present product on the household-, health-, agriculture humidification market. Humidifier market for data centers is very complex. There are few local seller, the biggest one is “JS HUMIDIFICADORES O ESPECIALISTA DA HUMIDIFICAÇÃO”, and there are so many import products from myriad countries. They are almost without exception, chose internet market to sale products.

- there are about 20 Portuguese companies which make humidifiers
- a lot of companies from other countries
- there rather make humidifiers which use the compressed air and running water, so our would be a good alternative for places where there is no running water – like DC
- companies which offers services specially for humidifiers almost does not exist
- however such a services are provided by companies dealing with air conditioning

5.2.7. SWOT Analysis :

Strengths:

- Ecological
- Product may be used in places where is no running water
- Cheap
- Low cost of maintenance
- No problem with suppliers – parts easy to get
- Technological skills
- Distribution channels
- Individual needs compliance
- Individual solutions
- Production quality
- Reliable product/service

Weaknesses:

- Lack of experience
- Lack of relationships
- Lack of developed distribution network
- Low budget
- Problems with communication with the clients
- Management

- Unknown brand

Opportunities:

- By selling via internet it is possible to get to more companies around the word
- Possibility to expand Polish, Catalonia , Spanish and Hungarian market, and around the world
- Build up distribution channels trough the internet
- Changing customer tastes
- Technological advances

5.3. Market Objectives and Strategy

Enter the market with new products, expand to the national market, designing products to solve the needs of all customers, develop specific control systems for each particular case.

5.3.1. Marketing Program

After finishing the prototype for data center of ISEP we have our first specific product to solve the humidity problems in a 80 m3 data center. We make a website to throw our product to the market. We explain here, how operate and how to use our prototype and we can adapt the humidifier to solve different humidity problems either different size of data centers or for another applications. We offer guarantee for 1 year and we have doing the maintenance. In the first time we will have a promotion to the another universities, with concerting visit's in ISEP'S data center and showing how operate our product. Then we contact with the responsible of data centers of local hospitals, banks, medium and large companies….Explain that if they use our products they can extend the life of our machines and they solve a lot of money.

5.3.2. Strategy to be competitive

Participate in events where we can showcase our product

Facilitate the payment for the customers

Finding suppliers in China to lower the price of our product

Have personal contact with each client and each case

5.3.3. Goals

- Enter and remain in the local market absorbing 30% of production.
- Expand to the national market.
- Promotional campaigns among potential customers.
- Increase the staff to develop new ideas.
- Receive industry recognition for our work.
- Obtain customer satisfaction.

5.4. Marketing Mix

5.4.1. PRODUCT

- our humidifier (controlled by web interface, 2 days of autonomy, friendly to environment, compatible with EU directives)
- possibility for determining the active area
- service (replacement of parts, solving problem with web interface)
- guarantee for 1 years

5.4.2. PLACE

- selling via internet with 30 day for testing
- website in different languages: English, Spanish, Hungarian, Polish, Portuguese
- possible chat on the website to ask questions directly
- in future few small shops

5.4.3. PRICE

The process of setting a price for the product, is for most companies a difficult process always thinking about the profit they can enjoy. Our definition of price was tried wondering if and only on the client. Our price offers a good cost benefit ratio. The our product have the following price :

Humidifier with a web interface : 499 € with 23% VAT included

marketing objectives
marketing mix strategy
costs
organizational consideration
competition

environmental factors

discounts for bigger humidifiers

stock of filters in promotion

5.4.4. PROMOTION

- ad in internet
- participating in EXPO
- discounts for known clients
- informational materials
- sponsored articles
- visiting potential customers
- presenting the prototype build for ISEP

5.5. Summary

It was observed that last few years people are more aware of influence of humidity level and due to that interest we decided to introduce a new humidifier, which is efficient, friendly to the environment and cheap to maintenance. Our humidifier has great potential – it can be suited easily to needs of customer, so it ensures customers' satisfaction.

To strengthen position of our company in the market we would like to provide also services associated with parts replacement and repair.

6. Project Development

The project started with a visit to the server room for which the humidifier was designed. We could see how much space there is and where it is possible to place the new equipment. Next step was to choose the type of humidifier – as it was stated we decided for the evaporative one. We were also considering ultrasonic or the one with air compressor, but this solution is the smaller and very economic.

6.1. Architecture

We had to design our own project, which would fit perfectly to the data center.

This evaporative humidifier consists of fan, pump, water tank, and cloth which is used as filter. Cloth should be wet all the time, so an aquarium pump sprays it with the water from tank. The fan sucks water from the cloth and then it blows it as small particles of water. It is controlled by the Arduino with Ethernet card, and it communicates with the humidity sensors, the water level sensors in the tank and the switches off and on a pump and a fan.

6.1.1. Fan

First, we thought about a typical domestic fan, but we did not know how to fix the filter. After that, we thought about a kitchen extractor because have a metal filter and we could change it. Moreover, it is possible to use the tray, which is under the kitchen extractor to return the excess water to the tank.

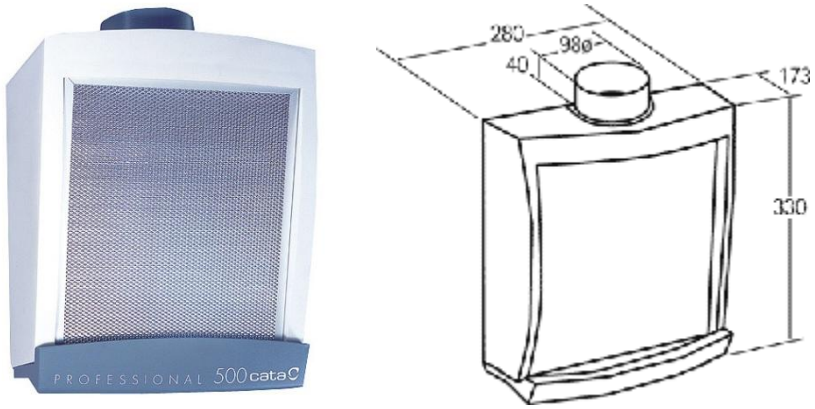

Fig , 5. Kitchen extractor

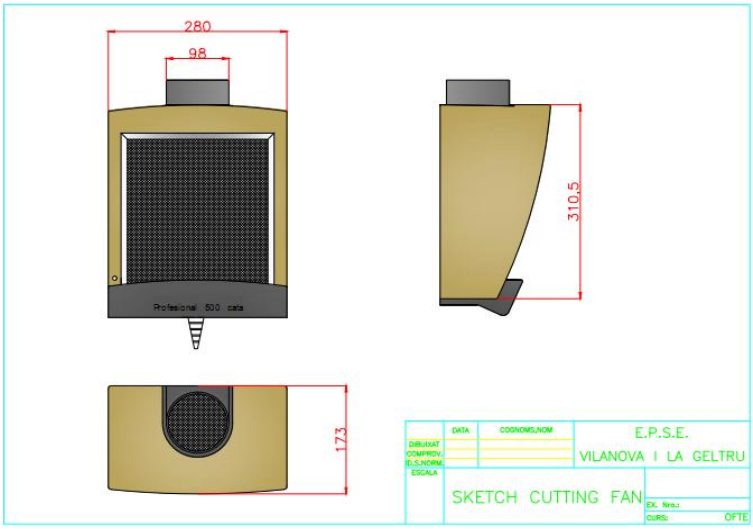

Fig. 6. Sketch of a fan

However, this idea was seemed good, it still needed some changes. We wanted water to flow on the filter, so we made a hole in left down side to put inside the extractor a pipe with a diameter 8mm. This pipe is fixed in a top of the filter. Then we made 8 holes in the pipe to flow the water. Finally we made another hole in the middle and in the front of the tray to return any excess of water back to the tank.

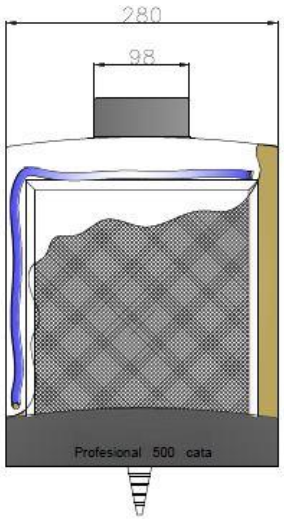

Fig ,7. Extractor modifications

6.1.2. Water tank

In order to find a water tank of proper size, we first made a chart with data about humidity and temperature in the data center. After that, we tried to calculate how many liters of water will be needed for the humidifier to work two days without refill. We used this website to help us: http://www.lenntech.com/calculators/humidity/relative-humidity.htm
It was difficult to calculate exactly how much water is needed because the temperature is not constant. However, we estimated that ten liters will be enough, even for the worst case when the humidity is very low. Moreover, we were looking for a tank with cover, which fit perfectly, in order to prevent vaporization of water.

Relative humidity 1m³(g)								
	15°C	20°C	21°C	22°C	23°C	24°C	25°C	30°C
10%	1,28	1,7	1,82	1,94	2,06	2,18	2,3	3
20%	2,56	3,4	3,64	3,88	4,12	4,36	4,6	6,1
30%	3,84	5,1	5,46	5,82	6,18	6,54	6,9	9,1
40%	5,12	6,8	7,28	7,76	8,24	8,72	9,2	12,2
50%	6,4	8,5	9,1	9,7	10,3	10,9	11,5	15,2
60%	7,68	10,2	10,92	11,64	12,36	13,08	13,8	18,3
70%	8,96	11,9	12,74	13,58	14,42	15,26	16,1	21,3
80%	10,24	13,6	14,56	15,52	16,48	17,44	18,4	24,4
90%	11,52	15,3	16,38	17,46	18,54	19,62	20,7	27,4
100%	12,8	17	18,2	19,4	20,6	21,8	23,1	30,4
Relativehumidity / 80m³ (g)								
	15°C	20°C	21°C	22°C	23°C	24°C	25°C	30°C
10%	102,4	136	145,6	155,2	164,8	174,4	184	240
20%	204,8	272	291,2	310,4	329,6	348,8	368	488
30%	307,2	408	436,8	465,6	494,4	523,2	552	728
40%	409,6	544	582,4	620,8	659,2	697,6	736	976
50%	512	680	728	776	824	872	920	1216

60%	614,4	816	873,6	931,2	988,8	1046,4	1104	1464
70%	716,8	952	1019,2	1086,4	1153,6	1220,8	1288	1704
80%	819,2	1088	1164,8	1241,6	1318,4	1395,2	1472	1952
90%	921,6	1224	1310,4	1396,8	1483,2	1569,6	1656	2192
100%	1024	1360	1456	1552	1648	1744	1848	2432

Fig ,8. Humidity and temperature chart 1m^3 and 80m^3

	Totalize Min. Humidity (%)	Totalize Max. Humidity (%)
Measured Values	33	67
Used Values	30	70
	Min. Temperature (°C)	Max. Temperature (°C)
Measured Values	18,8	25,4
Used Values	15	30

Fig ,9. Humidity and temperature chart

Fig ,10. Water Tank

When we finally found the proper tank, we still had to make some changes. We made two holes for the water level sensors. Before that, we calculated the volume and we decided to make the first hole when there are 6 liters of water in the tank – when the water level is below the first water sensor alarm is send. We made a second hole, when there are 3 liters in the tank – this is the minim an amount of water needed for the pump to work properly.

We made three holes in the lid of the water tank - one for the water pipe from pump to the extractor (Ø 8mm), a second for pump's electrical cable, and last one, the biggest, to return the excess water to the tank - this hole is protected with a rubber gasket.

To make refilling the tank easier, we cut the lid in two parts, and joined them with a hinge, and then we taped up to make it more hermetic.

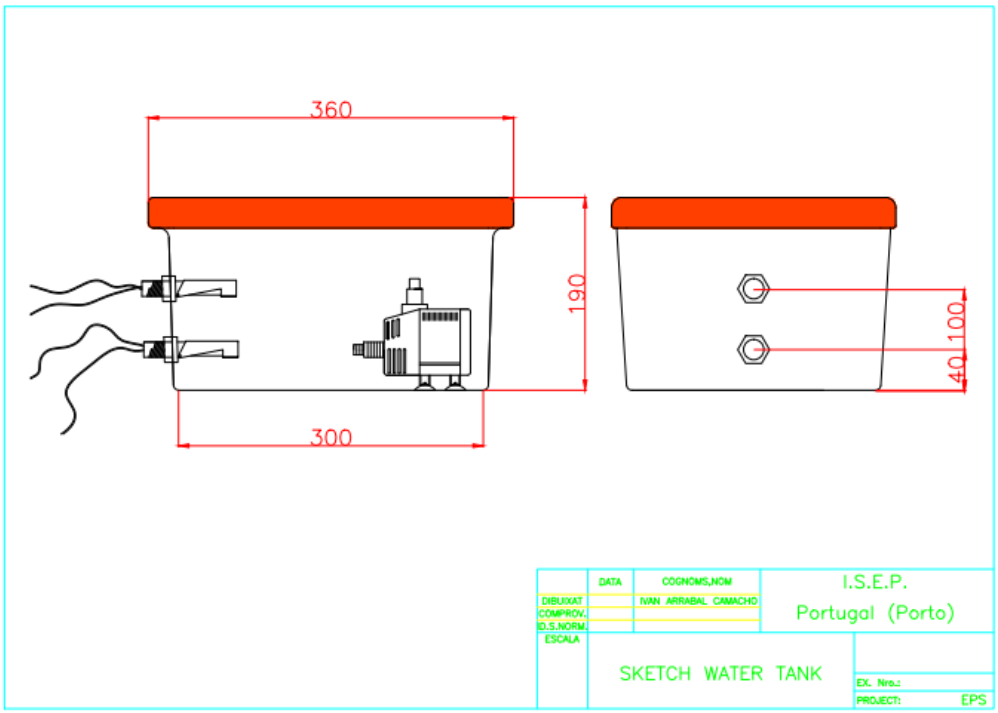

Fig ,11. Water Tank modifications

6.1.3. Structure

To set up all parts of the humidifier, we thought about a structure to organize all equipment. At the beginning we wanted to build it by our own, using aluminum, but later we found furniture for bathrooms, made of aluminum, and that seemed to be a perfect solution for this problem.

Fig ,12. Structure

This structure is very good for our needs. However, we had to modify it a little. We changed the metal platform in the lowest level and fixed another metal bar in the middle in order to fix the extractor. Finally, we fixed two 90º aluminum angles to fix the electrical box.

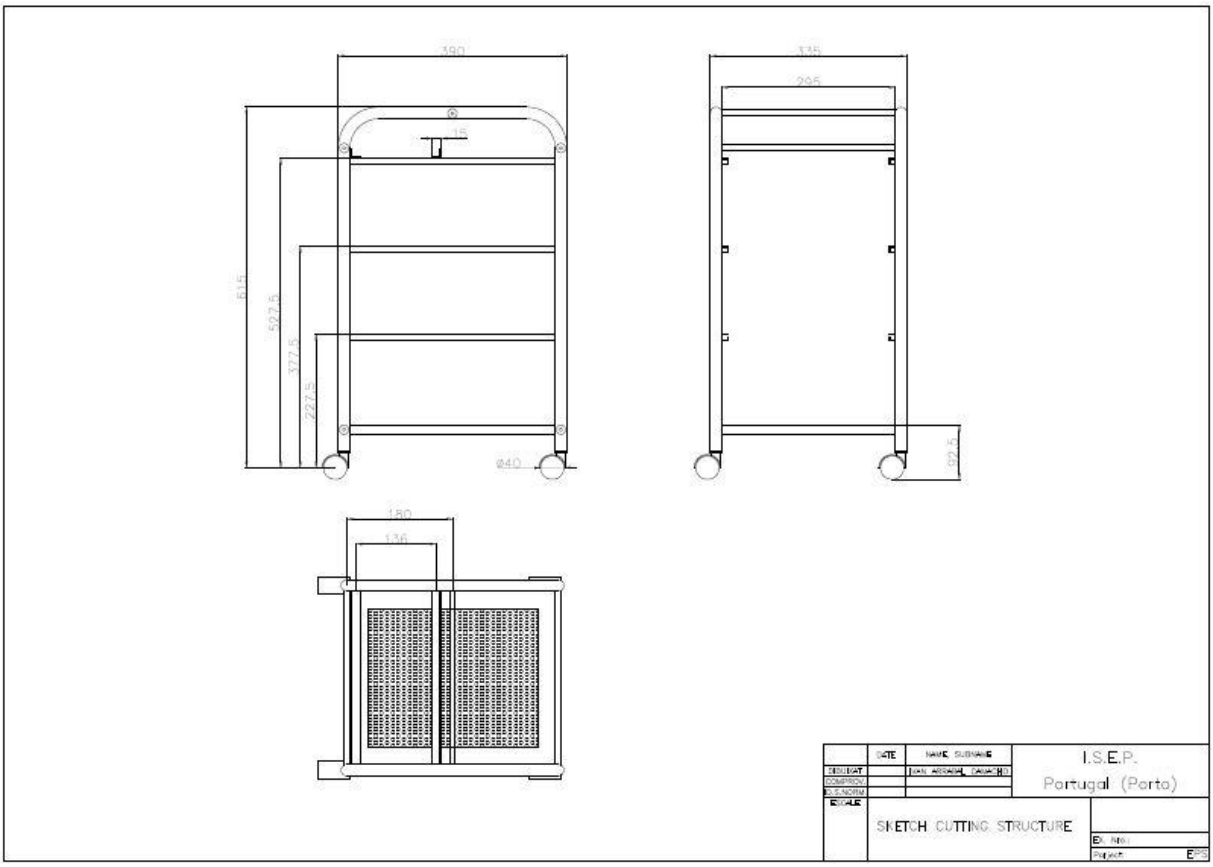

Fig ,13. Structure modification

6.2. Filter

We look for several materials which could be used as filters. We made tests for all of them. For this purpose we used a hairdryer, PC fans and different materials and we measured the humidity. With this test we also proved that our humidifier should work. We did two tests, because during the first one the measurements were incorrect, but we picked up three that seemed to be the best. During the tests we considered hygroscope, how fast it dries and the differences in the humidity. Finally, we decided for professional filter for humidifiers – although it is a bit more expensive, it is much more efficient and durable, so there will be no need to change it so often.
To improve the efficiency of our humidifier we decided to mix the professional filter and another filter from the kitchen "Vileda" (viscous fiber, polypropylene and cotton).

Fig. 14.Polypropylene and cottonfilter

Fig. 15. Professional filter

6.3. Controlling system

6.3.1. Control system:

This humidifier is controlled by an Arduino Uno. The Arduino Uno is a microcontroller board based on the ATmega328 . It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer, with a USB cable, or power it with an AC-to-DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features the Atmega8U2 programmed as a USB-to-serial converter.

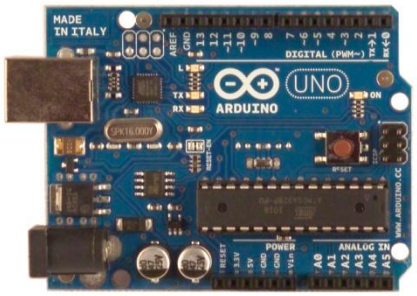

Fig. 16.Arduino Uno

Fig. 17.Arduino Ethernet card

An ethernet card is able to communicate with the Server computer and then retrieve the values of sensors and the ability to send data.
In accordance with customer expectations, the humidifier will use the three currently installed humidity sensors values and values of five more humidity sensors what will installed in the future , and will use one built-in sensor for the case when there is no network connection.

The ethernet connection will used for sending warning emails too when the water level is under the second safety level.
On the inputs are connected the two water level sensors, the built-in humidity sensor. The Fan and the pump are connected to Arduino outputs through relays. The warning LEDs are also connected on outputs or on a parallel way of the controlled part.
When Arduino gets the data from the server, check the date. If a date it's not available or the date is not correct, we don't use those values, and use instrad the lowest of the correct values. Based on this lowest value, Arduino switchs on the pump for six seconds, then turns on the fan for three minutes if the humidity level is under 55%. If the humidity level is under 45%, the working times change to longer. Above 55% don't switch on again the pump and the fan, and in all cycle sends a signal to relays to switch off the pump and fan.

The water level is monitored too, by two switchers. When the lowest water level sensor closed, it means not enough water in the water tank. Running without water is not allowed to for the pump; therefore, if not enough water, to switch the pump and fan is blocked, and send signal to relays to turn off. Furthermore Arduino send an email to José Oliveira of the data center about the water level when the level is under the second safety level.

6.3.2. Program:

6.3.2.1. Variables:

Global variables:

- const String s1 and const String s2: HTTP codes, between these two string changes the number of the humidity sensor to get humidity values from data server.
- const String s3: HTTP code to get date from the TomCat server.
- const int SENSOR_NUMBER: constant number of the humidity sensors in the data server.
- const int NOT_FOUND: constant variable to compare the reply if no data available.. Five sensors (from the eight) are not installed yet.
- byte mac[] : MAC address of Arduino.
- byte ip[] : IP address of arduino.
- byte server[] : IP address of the Data server
- int min_value: The minimum humidity value of the eight sensors of the data centre and the one built-in sensor.
- int water: is a flag for water level. If it's "1" the humidifier runs are allowed, if it's "0" it means that there is not enough water for the pump and the run is banned.
- int server_minutes:
- int sensor minutes:
- boolean email: is another flag for email sending. "0": email sending is allowed. "1": email send was successful and it blocking the email sending while the water has filled up.
- String server_date: the answer when the program calls the date from the server.

- String sensor_date: part of the reply that included just the date of the sensor.

Local variables:

1. Local_Humidity():
    - int LHS: current humidity level from the built-in sensor (read from analog pin 0).
2. Water_Control():
    - int WLS1: the first water level switch state (read from digital pin 7).
    - int WLS2: state of the second water level switch (read from digital pin 8).
    - String alarm: It's a message to the serial monitor about the water level.
3. SendMail():
    - Client Emailclient: availability of the email server.
4. getDataFromServer():
    - Client client: availability of the data server.
    - String extract_server_date: current date of the data server.
    - String extract_sensor: current date of the eight humidity sensor.
    - float getValue: humidity level from the eight sensor.
        - int finish: end of the humidity value in the reply.
        - float res: value of the humidity (8 sensors) from the reply in float format.
        - String roi: value of the humidity (8 sensors) from the reply in string.
    - String reply: the answer of the data server that includes sensor Id-s, dates, and the humidity values. From this reply we have to take out the important data.
    - int getHours: this string gets the hours from the time .
        - int h: number of hours.
    - int getMinutes: this string get minutes from the time.
        - int m: the number of the minutes in the current time.
    - String getTimeInMinutes: thin string converts hours and minutes from the current time to minutes.
        - (1)int counter: counter 1-8.
        - (1) int nchars: number of the characters.
    - getDate():
        - (1)char c: one character from the date reply, changes letter by letter.
        - (2)int nchars: number of the characters.
    - getHumidity():
        - (2) int counter: counter 1-8.
        - (2) char c: character from the reply, changes letter by letter.
        - int value: eight humidity values.

6.3.3. Main parts of the program:

6.3.3.1. Void setup*:*

In this part, the program sets the pins of the Arduino to outputs or inputs. Furthermore, it initializes the connection to the data server.

```
void setup()
{
  pinMode(2, OUTPUT); //FAN
  pinMode(4, OUTPUT); //PUMP
  pinMode(9, OUTPUT); //Connection LED 1 (disconnecting)
  pinMode(7, INPUT); //WLS 1
  pinMode(5, OUTPUT); // WLS 1-LED
  pinMode(8, INPUT); //WLS 2
  pinMode(6, INPUT); //WLS 2-LED

  //start the serial library
  Serial.begin(9600);
  Serial.println("Initialising...");

  // initialises the Ethernet card:
  Ethernet.begin(mac, ip);
}
```

6.3.3.2. Humidity control based on local humidity sensor:

These seven lines read the value from the local humidity sensor and put it into the “min_value” if it more low than the “min_value”. The “min_value” variable is that variable what the program uses as current humidity value.

```
void Local_Humidity()
{
  int LHS = analogRead(0) / 10.23;
  Serial.print("LHS:");
  Serial.println(LHS);
  if ( min_value > LHS ) min_value = LHS;
  Humidity_Control(min_value);
}
```

6.3.3.3. Fan and pump control:

The real part of the humidity control; in this part we control when it is the time to turn on and off, and for how long will run the pump and the fan, if the humidity level is under 55%.

```
void Humidity_Control()
{
  Serial.println(),
  Serial.println("Humidity Control");
  Serial.print("Min Value:");
  Serial.println(min_value);
  Water_Control();

  if(min_value>70)
  {
    Serial.println("WARNING: Humidity Level Critical High!");
  }
  if(min_value<55)
  {
    if(water==1)
    {
      digitalWrite(4, HIGH); //Activate Pump
      Serial.println("PUMP ON");
      delay(10000);
      digitalWrite(4,LOW); // Deactivate Pump
      Serial.println("PUMP OFF");

       digitalWrite(2, HIGH); // Activate FAN
       Serial.println("FAN ON");
       delay(240000);
       digitalWrite(2, LOW);
       Serial.println("FAN OFF");
    }
   }
```

6.3.3.4. Connection to Data server:

"void Connection () " makes the connection between the TomCat server and Arduino. If the connection is not successful, and it repeats the process again and again while not connect. For the period, while the connection is not established, the program will use just the local humidity sensor values.

```
Client client(server, 8080);

void Connection()
{
  Serial.println("Connecting to Data server");
  // start the Ethernet connection:

  while (!client.connect())
  {
    Serial.println("Trying to connect");
    digitalWrite(9, HIGH); // led internet
    Local_Humidity();
    Water_Control();
    delay(1000);
  }
}
```

6.3.3.5. Connection to email server:

It's the a similar process as "void Connection()", but here the Arduino is connecting to the email server.

```
Client Emailclient(server, 25);

void EmailConnection() {
  Serial.println("Connecting to Email server");
  // start the Ethernet connection:
  if (!Emailclient.connect()) {
    Serial.println("trying to connecting");
    delay(500);
  }
}
```

6.3.3.6. Sending email:

This module sends a water level warning email.

```
void SendMail()
{
  if (!Emailclient.connected()&& email==0) EmailConnection();

  if (Emailclient.connected()) {

    Emailclient.println("HELO mailserver.isep.ipp.pt");
    delay(500);
    Emailclient.println("AUTH LOGIN");
    delay(500);
    Emailclient.println("MTA4MDU2MEBpc2VwLmlwcC5wdA==");
    delay(500);
    Emailclient.println("TWFUV0JQUkc=");
    delay(500);
    Emailclient.println("MAIL From:<l101676@isep.ipp.pt>");
    delay(500);

    Emailclient.println("RCPT To:<galpg@hotmailcom>"); // demon@isep.ipp.pt
    delay(500);

    Emailclient.println("DATA");
    delay(500);

    Emailclient.println("Subject:  Humidifier G1: Humidifier Warning");

    Emailclient.println("G1 Humidifier: Water Level Warning - Please fill up the water.");

    Emailclient.println(".");
    delay(500);
```

6.3.3.7. Operation cycle:

```
void OperationCycle()
{
  getDataFromServer();
  Local_Humidity();
}
```

There are three more functions in the program. One is to call the current date from the data server, than call the date of values and compare them. The program will ignore values with incorrect date. And in another function the program gets the humidity data from the server. In the case when “no data available” or the value is 0 will ignore too.

6.4. Electrical and electronic parts

In the Arduino board we have two inputs and two outputs. We had to control the extractor and the water pump. To control it, we chose two relays (FINDER 40.31 6V DC) *datasheet* (http://uk.farnell.com/finder/40-31-9-006-0000/relay-pcb-spco-6vdc/dp/1169157) because the Adriano’s outputs it works in 5V and the coil it can works.

But we have a problem because the current it's the maximum that Arudino’s can hold, and to prevent this we made and electronic additional circuit.

To activate the relay coil used a transistor (BD137) in case the power Arduino gives us is not enough, and we also use a protection diode (1N4001) to remove the current induced by turning off the coil.

We need to calculate the resistance of the circuit.
Using the transistor BD137 with hfe = 170 :

$$Rcoil = 55\Omega$$

$$V = 5V$$

$$I = \frac{5V}{55\Omega} = 0{,}09\ A$$

$$hfe = \frac{Ic}{Ib} => Ib = \frac{Ic}{hfe} = \frac{0{,}09A}{170} = 5{,}29 \cdot 10^{-4}A$$

$$R = \frac{Varduino}{Ib} = \frac{5V}{5{,}29 \cdot 10^{-4}A} = 9481{,}80\Omega$$

We choose one of 10KΩ.

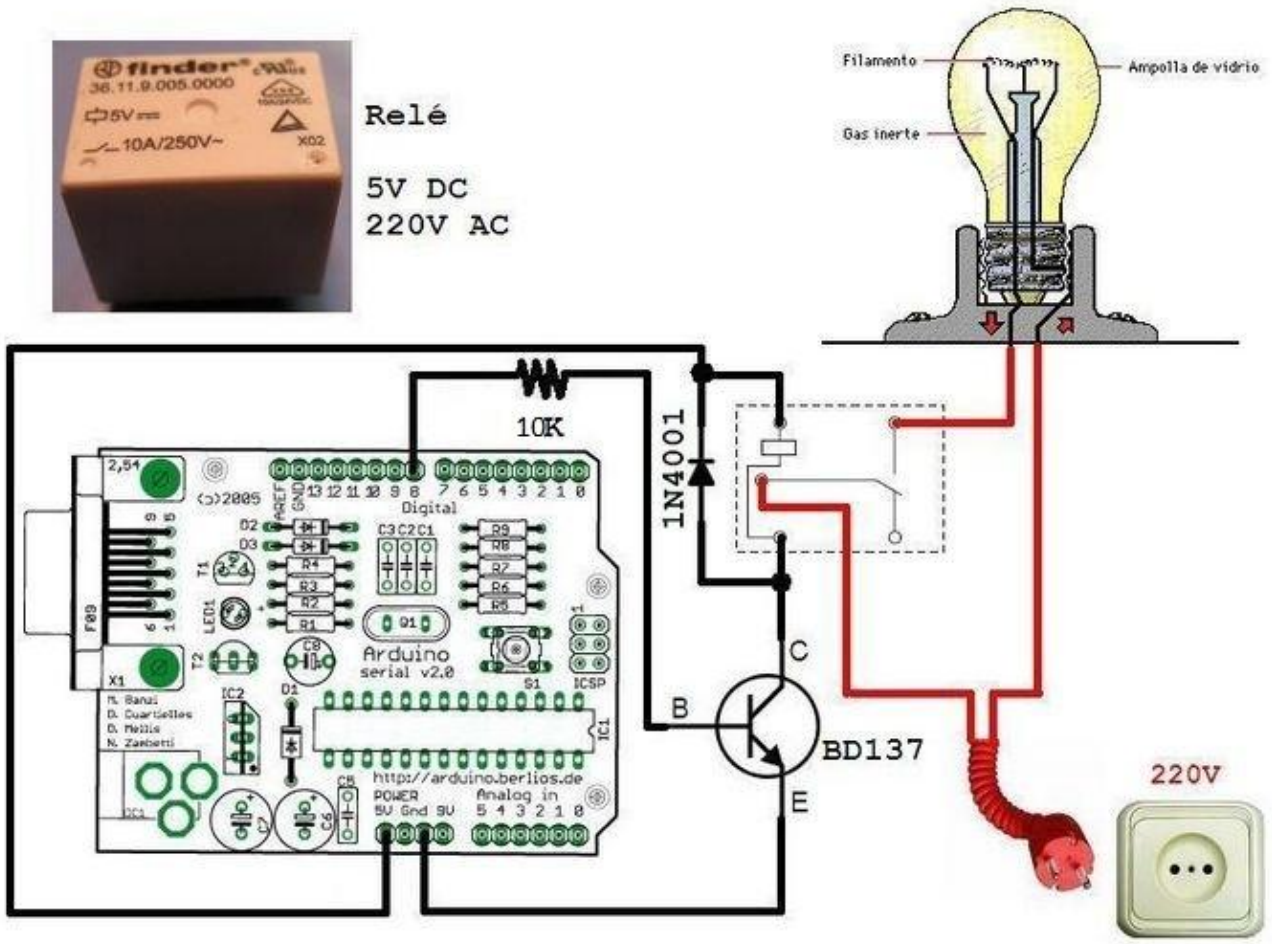

Fig. 18.Relay additional electronic circuit

We had another problem because the switch is not a commutator, and the input of Arduino needs a real 0 to understand the 5V from level sensor.
We put a resistance of 10KΩ to do the commutation.

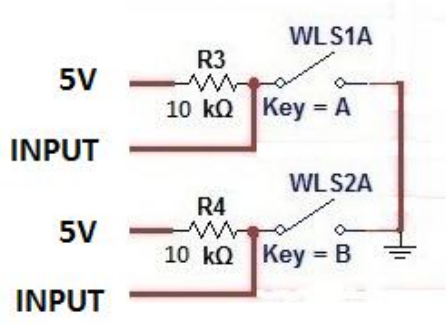

Fig. 19. Sensors additional electronic circuit

We needed a power supply to convert 230V AC to 12V DC because Arduino it's working in this voltage.

Fig. 20.Power supply

6.4.1. Electrical and control sketch :

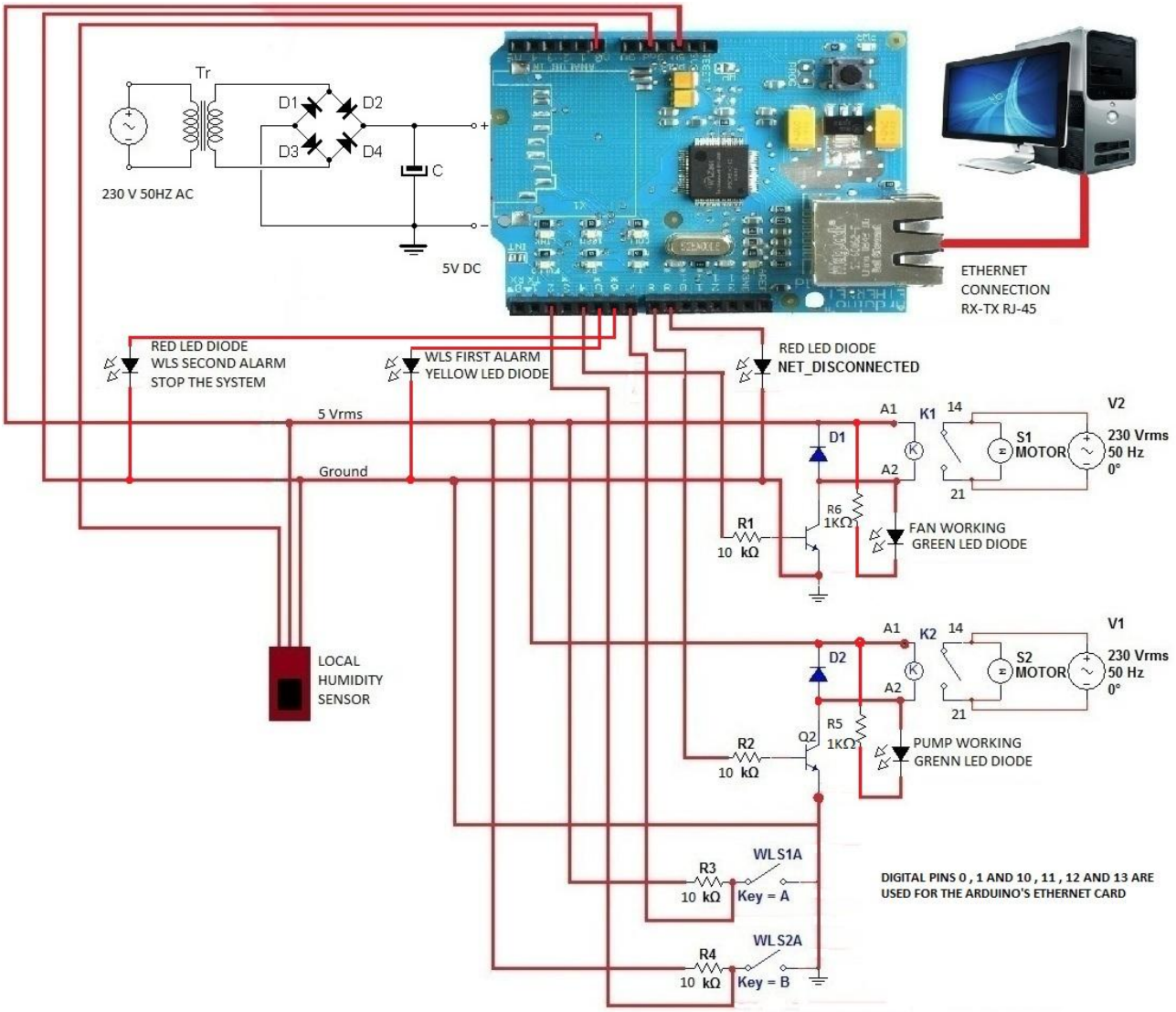

Fig. 21.Electrical and controlling sketch

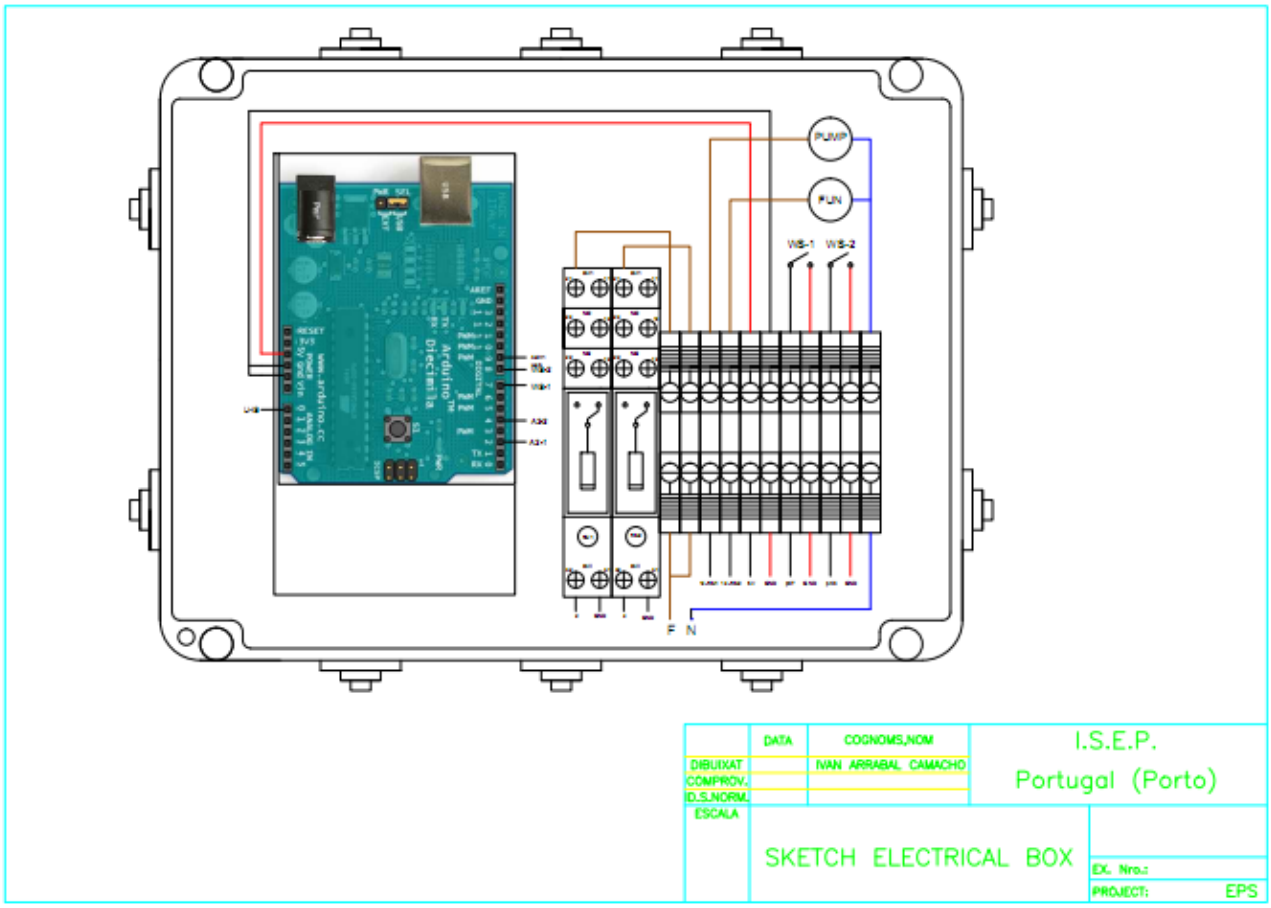

Fig. 22. Electrical box

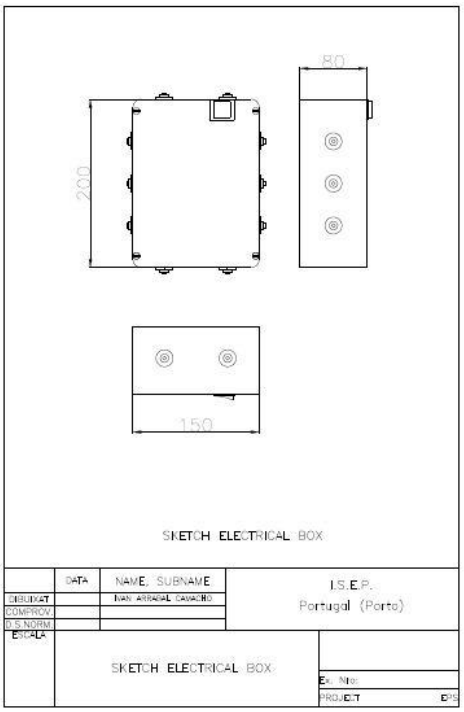

Fig. 23.Electrical box

6.4.2. Final model of evaporative humidifier:

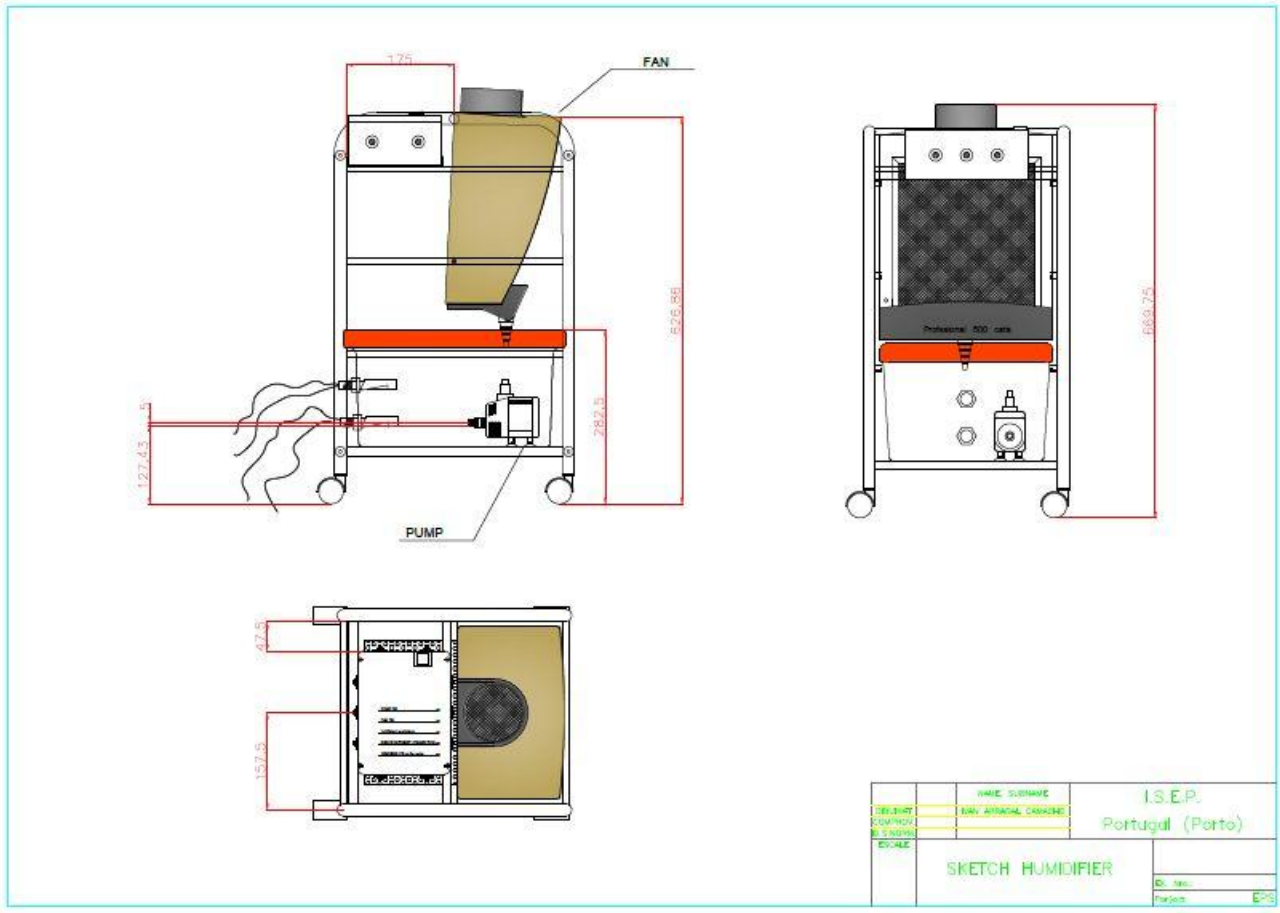

Fig. 24.Final model of humidifier

Fig. 25.Final model of humidifier

Fig. 26.Final model of humidifier

Fig. 27.Final model of humidifier

7. Material List

Material	Unidade	Reference	Total Price
WL sensor	2	Water level sensor switch 5V	17,94 €
Microcontroller	1	Arduino UNO ATmega328	23,75 €
Ethernet card	1	Arduino Ethernet Shiel	35,06€
Microcontroller Box	1	Arduino Box	12 €
Filter	1	Humidifier professional carbonic filter	32€xm^2
Filter	1	Vileda	1,25€
Humidity sensor	1	HIH-4030 Humidity Sensor Breakout	13,75 €
Fan	1	Extract cozinha Professional 500	44,95 €
USB lead	1	USB lead	4,45 €
Tank	1	Water plastic tank 16 L	7,75 €
Water Pump	1	Sicce Syncra Silent 0,5	21 €
Pipes	2 (m)	Plastic pipes Ø8mm	2,5 €
Electric Lead	3 (m)	Electrical lead 3x1,5mm^2	3 €
Relay	2	FINDER 40.31 6V DC	2,4 €
Transistor	2	BD137	0,20 €
Diode	2	1N4001	0,20 €
Diode Led	5	2 Red diode, 2 green diode, 1 yellow diode	0,50 €
Electrical Box	2	Electrical box 200x150x80 mm	5,25 €
Resistance	4	Resistance 10KΩ	0,05 €
Resistance	2	Resistance 1KΩ	0,05 €
Structure	1	Vidaliny Ruth	28 €
Switch	1	230V green switch	1 €
Hinge	2	35x22mm ac.INOX	3 €
Bread Board	1	Breadboard 20x10cm	2.25 €
Water pipe reducer	2	Water pipe reduces Ø 16 to Ø 8	6 €
Relay base	2	Finder 40.31 SERIES SOCKET TYPE 95.13 RC	3,25 €
Ethernet connector	1	Lan Connector	4,24 €
Computer power connector	1	230V Computer connector	1,5 €
Screw and vises	10	Screws and vises Ø5mm	2 €
TOTAL			
279,30€			

8. Functionalities

Beyond humidifying, it has some additional functions too. It sends data to the TomCat server about the two water level switchs state and also sends an e-mail when the water level falls below the allowable.

9. Conclusions

Discussion

We had a few problems during performing our project. Our greatest problem was the fact that no one of us had an experience in this type of work. We had problems with team work, but finally we managed to find a solution. Moreover, no one of us had an idea about humidifiers or web interfaces. We also had a great problem with lack of motivation, but fortunately we mobilized ourselves.
While looking for good solution, we could not decide which type of humidifiers will best suit all needs. We were considering ultrasonic humidifier, but we realized it is very complicated and creates additional problems. So, finally, we decided for an evaporative humidifier as it combines good humidifying without a risk of too much humidity in air and simplicity during building.
As it was mentioned we had to repeat testing filters, as the measurements were incorrect.
We had also some problems how to connect the electrical switchers to Arduino and we need to created a circuit from a transistor, a 10KΩ resistor and a protection diode, cause not allowed to connect Arduino directly to the coil.
We had the most problems with program writing, because none of us have got skills or experience with Arduino's program language, or with another program language. We have some study about C and C++ language but just in very basic level. The most complicated part for us was to get and check the data and the date from the TomCat server, for this part we needed some help.

10. Further Developments

- Make coverage around the structure;
- Additional functions based on individual needs (in program or in architecture);

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