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ELECTRONIC SYSTEM APPLIED TO MASS MOVEMENT COFFEE IN SOLAR DRIER

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SUMMARY

It is an effort aimed at solving a problem presented in a farm in the municipality of Saladoblanco south of Huila department, where coffee is grown mainly work developed. To dry the coffee beans for further processing a solar drying is used, in which the farmer must enter and move the coffee beans to dry evenly, withstanding high temperatures and spending considerable time. It is in the drying room where the need to improve the procedure was carried out manually and use technology to improve the quality of life of the farmer, therefore, consequently an electronic and mechanical system was installed for attaining the movement of grain comes of coffee throughout the solar dryer, activated wirelessly using bluetooth communication between the aforementioned system and smarphone. Figures of mechanical systems implemented in the solar dryer with sprockets, steering wheels, chains and AC motor of a horsepower, which moves a rake moldboard along the drying room are presented, making the movement of grains coffee. For motor control, a small card to activate and deactivate an ATmega328 microcontroller was designed; to take data from the temperature and humidity sensor and a communicator DHT11 the HC-06 bluetooth 30 meter range was used.

Keywords: environmental, bluetooth, coffee, control, electronics, microcontroller, health, drying room, sensor, solar.

1. INTRODUCTION

One of the most important processes in the agricultural sector where they could use solar energy was drying grain, because of its high diversification across the country, and the need to reduce moisture in order to store them safely "(Restrepo and Burbano, 2005). In the process of coffee production should be dried grain for further processing, one of the possibilities, solar drying, widely used by farmers who implement structures that allow radiation solar hot air inside the dryer to reduce grain moisture to a 12% wet basis (Berrueta *et al*, 2003). Looking to make a contribution to the technological development of the Huilense region, first in national coffee production and taking into account that "the contributions of engineering are key to the economic, environmental and social sustainability of coffee production" (Oliveros and Sanz, 2011) an electronic system to move the mass of coffee in solar dryer designed and implemented with a simple methodology that allowed move the grain for uniform drying with a rake moldboard within the solar drying, controlled wirelessly so that health is cared developed personnel performing the work of movement of the mass of coffee inside the solar dryer since there would be no need to enter the hours of higher temperature up to 50 ° C (Ramirez *et al*, 2002), as well as solar energy also takes advantage directly.

To fulfil the objective knowledge of different areas such as analog electronics, digital electronics, microcontroller programming, calculus, physics and mechanical application of process automation they were used. With new robotic developments in the field of agriculture, have implemented complex and efficient systems to contribute to the development of the agricultural sector and implement the new technology in the field, then it is time to reflect on what are the possibilities to support the agricultural sector in the region and also to generate knowledge to job creation and quality of life for the inhabitants of the cafe regions. The procedure involves an investigation of the state of the art that recognized applied to solar dryers for temperature control systems, and humidity necessary for good drying coffee bean and higher product quality, then the system of coffee mass movement is a contribution to the development of technology applied to agricultural processes. The system implements an AC motor for moving a rake along a solar dryer, a microcontroller atmega 328 to handle data and execute the scheduled process, high power relays, integrated circuits such as temperature sensor and humidity DHT11, and other elements for an appropriate control system.

The mechanical system consists of a pair of rails by which roll stands rake extending widthwise of the dryer, also has a speed reducer which allows lower motor revolutions 1750 rpm to obtain at the output 150 rpm.

2. METHODOLOGY

The project was oriented towards an integrated system that was developed through the following steps:

A. Mechanical system selection

Guide rails on either side of the dryer were placed to slide over these wheels rake moves along the dryer, see Figure-1 and Figure-2. This prototype was implemented in the dryer shown in Figure-3.

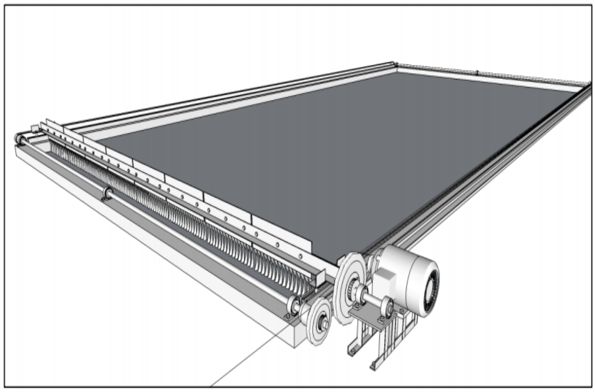

Figure-1. Sketch up software graph. Model proposed prototype.

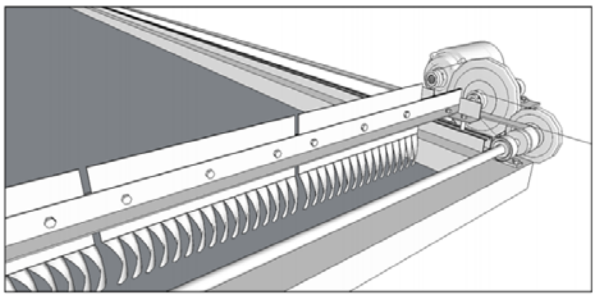

Figure-2. Rake rails and prototype.

Figure-3. Prototype solar dryer.

The system has a reduction to decrease in the shaft having the chain that drags the rake, the number of revolutions since the engine gives 1750 rpm, which when connected directly cause a very high speed and strong momentum that could damage engine or any other part of the mechanical system, see Figure-4. It can be seen flyers system, the engine and transmission circuit in Figure-5.

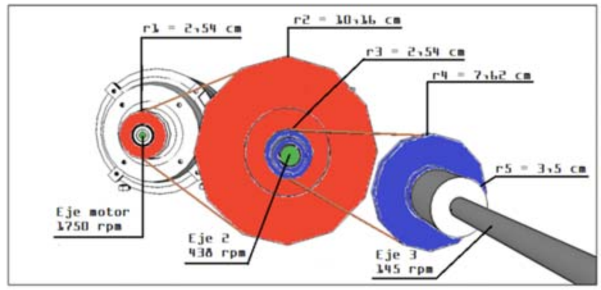

Figure-4. Reduction system speed.

In Figure-4, it is possible to observe the differences between the radii of the flyers that make the reduction system, the ratio of differences in (1).

$$relacion = \frac{r2}{r1} \times \frac{r4}{r3} = (\frac{10{,}16\ cm}{2{,}54\ cm})x(\frac{7{,}62\ cm}{2{,}54\ cm}) = 4 \times 3 = 12 \quad (1)$$

Where r1, r2, r3, r4 are the radii shown in Figure-4. This rotational speed of the engine is reduced by 12 times about the main axis 3, so if the rotational speed of the engine is 1750 rpm the main shaft rotates at 145 rpm.

Figure-5. Reducing speed, motor, circuit box.

The pinion bearing chains that move the rake has a radius of 3.5cm, from which it follows that the displacement by rotating the rake would be the circumference of the pinion, see (2).

$$Desp/_{giro}\Big| = 2 \times \pi \times r = 6{,}28 \times 3{,}5\ cm = 21.98\ cm \quad (2)$$

Considering the motor speed, the speed would rake as in (3).

$$Vras = rpm_{piñon} \times circunfere_{piñon} = 145rpm{*}0{,}22m = \frac{31m}{min} = \frac{0{,}5m}{s} \quad (3)$$

B. Design Electronics

Basically it was necessary to design four subsystems for both prototypes, which are coupled as

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shown in Figure-6: Driver power and voltage regulation, sensors, communication and processor.

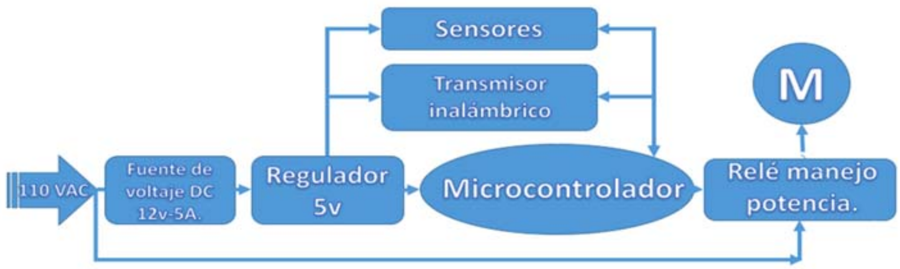

Figure-6. Electronic system block diagram.

From this it follows that the maximum power of the system means a maximum current of 1,67A enough to allow movement of the mechanical system.

Design of power controller and voltage regulator

The design parameter was the consumption power of an engine 20 watts to enable digital control for operating same, in an initial prototype of size 30 cm x 40 cm.

$$P = VI \quad (4)$$

V = Voltage
I = Power

A maximum power, i.e. P = 20W, proposing a voltage 12v and replacing in (4), is obtained (5).

$$I = \frac{20W}{12v} = 1{,}67\ A \quad (5)$$

From this it follows that the maximum power of the system means a maximum current of 1, 67A enough to allow movement of the mechanical system.

Based on the above it was decided to use the L298 integrated circuit that can handle DC voltages up to 50V and current of 2A. This means that meets the requirements to power the motor. Basically with TTL input pin is activated or deactivated outputs handle increased power up to 100 watts.

Since the control pins are TTL compatible, these were activated through a Arduino One card operating with a ATmega328.

The system required a 5v voltage level to power the various integrated, thus a 5v voltage regulator is added with a maximum current delivery 1A, sufficient for circuits implemented.

This subsystem allows the handling of the power required for engine operation and the mechanical system, and serve as power supply for the other subsystems. The circuit is shown in Figure-7.

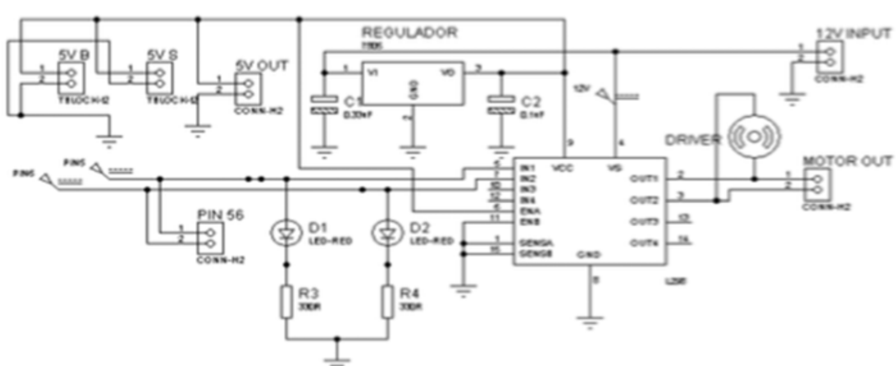

Figure-7. Power controller circuit and voltage regulator.

As noted in Figure 8), and, b) the initial prototype behavior with 100% PWM consumes about 15W, with a rake 30cm, if the rake had 1 m then consumption would be approximately 50W.

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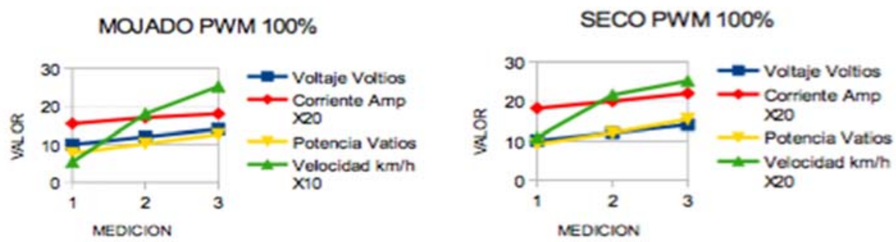

Figure-8. (a) Initial prototype ground coffee PWM 100% (b) Initial prototype dry coffee PWM 100%.

From the above it is possible to deduce that for a drier 4m wide is needed to sustain design power consumption four times larger, ie 200W. Anticipating that there are quantities of coffee that may cause greater friction force and the rake has a greater weight was relevant design with margin consumption, so the system was designed to handle a load of 800W that is a horsepower approximately.

To control on, off, and changing the motor rotation AC high power relays were implemented, capable of handling 30 A with an alternating voltage of 110, see Figure-9.

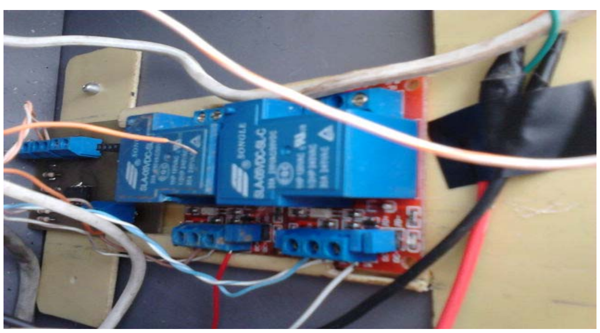

Figure-9. Rotation change relays AC motor.

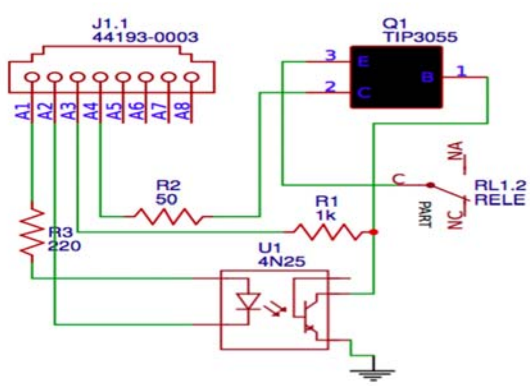

Figure-10. Circuit board relay.

Sensors

Inside a solar dryer it has a temperature variation between 10 ° C to 50 ° C and the speed with which the movement of the coffee takes place inside the dryer may be from 0.3 to 0.6 meters per second and coffee movement frequency is 3 times per day. For the census of temperature and humidity it was elected DHT11 device that meets the requirements previously required (range of temperature and humidity) and delivers a digital signal with the information to be processed by the microcontroller.

For the census of displacement and speed in the prototype January 1 CNY70 sensor, which detects whether it is white or black standing in a circle with subdivisions that is attached to the motor so used that when rotated, rotates the circle, then a voltage change is generated in the sensor output.

The sensor subsystem is formed by the sensor and CNY70 DHT11 sensor along with a signal processing output of the displacement sensor which is analogous stage. It has two output pins that are connected to the microprocessor. See Figure-11.

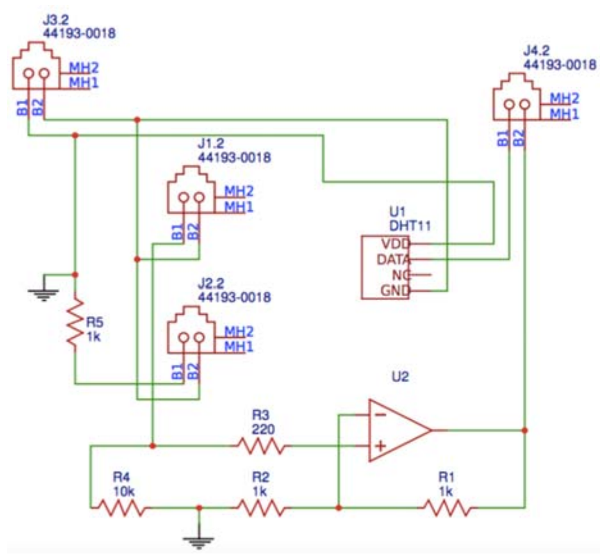

Figure-11. Sensor circuit.

Communication

For communication HC-06 Bluetooth card so that the microcontroller transmit data to a mobile device with a maximum range of 30 meters was used.

Processor

As processor microcontroller ATmega328 was used and was programmed to perform reading sensors, controlling the power of the DC motor to the prototype 1 through the power controller and the prototype 2 via relay

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card high power, also the microprocessor is responsible for communicating with a mobile device wirelessly.

Software development required

With the development of the system was necessary to program in a language chosen by feasibility allowing interaction with the user to carry out control and monitoring system. For this project, a program APP inventor, via web, allowing the implementation of a mobile application on Android operating system to display the data of temperature and humidity as well as to turn on and off the system, see Figure-12 is developed.

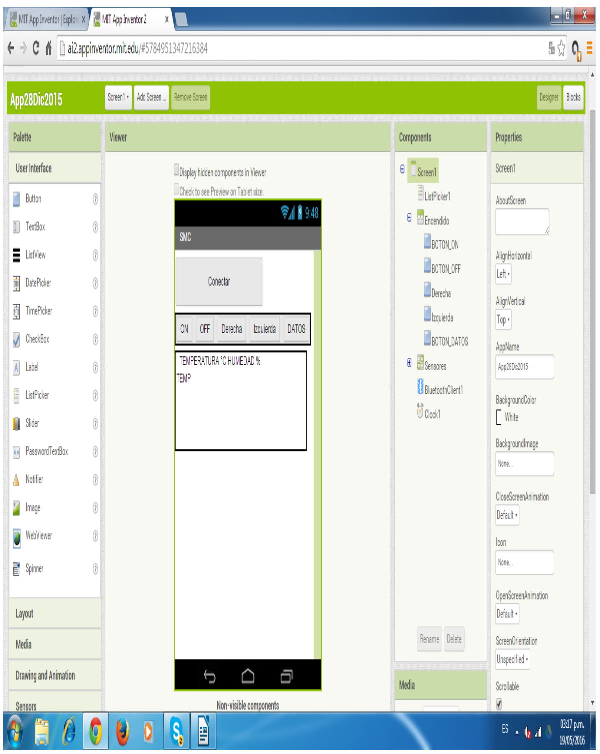

Figure-12. Mobile application.

RESULTS

It was possible to implement two prototypes for the mass movement of coffee, with temperature sensors, humidity and remote control via bluetooth. As evidenced in Figure-3, the initial prototype with its structure helped to devise the first solutions to the problem, since for its operation was required to control the DC motor, work activation and deactivation of the prototype from an application made in AppInventor, the first data sent to the microcontroller atmega 328, to start and stop the DC motor. As it was also observed that the rakes, although it was the first idea, did not allow a good step of the grains, and even much accumulation of grains could tell at the ends of the wooden base, so it was a big help input moldboard rake, which as shown in Fig 5 has tips that allows passage of the grains while going turning. For the prototype solar dryer, it was initiated by placing the rails seen in Figure-3 and Figure-5, the left and right of the concrete base plate on which is scattered coffee subsequently hand, the axes were placed end that properly rotated with the bearings and which were soldiers sprockets that lead the chains to move the rake made up of 8 sheets of PVC thermoformed as rakes moldboard that together covered the 4 meters wide of the dryer as shown in Figure-3. therake is supported by two metal angles bolted to the chains and carriages rolling on the rails.

Grain distribution is uniform and the movement of grain is suitable as shown in Figure 3, is noted that initially the grain should be spread throughout the area so that when the rake through doing their job no problems arise too large differences in the layers of coffee, or friction with coffee overcome friction reduction in flying and the band slide paralyzing the movement of the rake.

The system performed well with the load of coffee to 3 cm and that showed that power calculations were consistent and that no overheating occurs in the engine exceed its capacity, but stresses that in case of jamming, is slide the band one of the flyers and the engine at full power consumes energy. They can occur jams grains when walking on the tracks fall into them and obstruct the passage of carts and who controls the engine from your cell phone should watch from outside the drying room, watching the rake to stop, change the direction of rotation and turn again, and without having to withstand the high temperatures that can occur on a sunny day.

The system is subject to future changes for its improvement to provide better service and make changes that may take place.

Figure 8 a) and b) it can be observed that for speed, power consumption is similar, so if the work can be done faster, saving energy is presented, since consumption is presented for less weather.

4. CONCLUSIONS

The results were satisfactory since the grain moved and distributed evenly throughout the backer board prototype, see Figure-3.

The CNY70 sensor used for power control and measure the movement of the trolley in the system of linear displacement allowed for power control and scheduling back and return the cart, to make the process as many times as necessary in the initial prototype.

The final race sensors give a good performance to stop the engine and allow power relay start and stop the engine will of programming the microcontroller.

With the system running if sometimes some coffee beans ended on the rails, causing clogging of the system, it would be desirable in the near prototype that the rails outwardly so as not to fall grains within presented from them.

Wireless communication was appropriate and allowed release information of temperature and humidity on a mobile phone as well as activation and deactivation of the system in real time.

The system is ready for future modifications and can be a useful tool in the investigation of processes of drying coffee beans and other agricultural applications, as there are situations profitability and efficiency of the

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system to improve, since for coffee with this quality it requires adequate payment to cushion the costs of installing the system.

The prototype managed to move the mass of coffee along the dryer 8m long by 4m wide and together with the rake moldboard he managed to move the coffee beans properly, both in one direction or the other.

Comparing Figure 8 a) and b) is evidence that when you have a higher speed, power consumption is lower and to this is added that the work is done in less time, meaning energy savings and therefore cost.

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