Bean cleaner prototype using programable logic**Prototipo limpiador de frijol aplicando dispositivos lógicos programables**

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Abstract

The project focuses on the cleaning of beans through the separation of impurities by screening machines, with the aim of helping small farmers who grow and sell their beans. Beans are among the most consumed foods; however, the cleaning process is tedious, so we want to develop a system that performs such process in different stages of selection. Grains vary in price and quality in different places due to the conditions in which they are sold. This is because when they are sold in a supermarket, the product must be considered first level, which means, they must be of a homogeneous size and clean of any type of garbage. The purpose of this prototype is to clean the beans in such a way that it separates the impurities they might have and obtain a clean product. We begin by defining the cleaning procedure, then performing the structure and placement of sensors and actuators, and finally the programming and adjustments necessary for its operation. With this prototype, people who cultivate and extract the seeds can perform the cleaning and generate greater profits.

Resumen

El proyecto se enfocada a la limpieza del frijol mediante la separación de impurezas por medio de cribadoras, esto con el objetivo de ayudar al pequeño agricultor que cultivan y venden su frijol. El frijol es uno de los alimentos que se encuentra dentro del top de los más consumidos, sin embargo el proceso de limpieza resulta tedioso, es por ello se quiere desarrollar un sistema que realice dicha limpieza en diferentes etapas de cribado. El frijol varía de precios y de calidad en distintos lugares debido a las condiciones en las que se vende, esto se debe a que cuando se comercializa en un minisúper o supermercado, el producto debe ser considerado de primer nivel. Esto quiere decir, limpio de cualquier tipo de basura y tamaño homogéneo. Este prototipo tiene como finalidad limpiar el frijol de tal manera que separe las impurezas que pudiera tener y se obtenga un frijol limpio. Iniciando por definir el procedimiento de limpieza, posteriormente realizar la estructura y la colocación de sensores y actuadores y por último la programación y ajustes necesarios para su funcionamiento. Para quien cultive y extraiga la semilla, pueda realizar su limpieza y genere mayores ganancias con este prototipo.

Screening, Process, Oblong**Cribado, Proceso, Orificios oblongos**

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Introduction

Bean is a crop that has historically been associated with the development of pre-Hispanic cultures, and currently plays a primary role as a traditional crop in several regions of the world. In Mexico, the *Phaseolus vulgaris* L. variety is the second most important product in the agri-food sector, not only because it is a source of income for thousands of producers, but also because it occupies an important place in the population's diet, mainly that of the lower income social strata (Siacon-sagarpa, 2016).

Grains and cereals harvested manually or mechanically always contain impurities. The impurities normally found in agricultural products are usually fragments from the plant itself, such as stubble, leaves, grain pieces, branches, etc. Likewise, there are other impurities that do not come from the plant itself, which are called foreign matter and that are generally made up of wild seeds, part of other plants, lumps, sand, stones, etc. The impurities present in agricultural products are a consequence of carelessness during cultivation, mainly in the control of weeds, and the methods used for harvesting.

For the conservation of grains during storage, it is necessary to consider two important aspects of impurities: One of them is the fact that their presence makes the conservation of grains more difficult; and the other refers to the difficulty they present for the proper operation of the storage units. The excess of impurities negatively influences the conservation of stored products because they are normally hygroscopic and tend to moisten the grains, in addition to being favorable means for the development of insects and microorganisms (F.A.O, 2019).

The biggest problem in this type of harvest is the cleaning process to be implemented, since the product regularly has impurities, such as dirt, stones, branches or some other type of garbage that falls when it is extracted. This is a problem for those who grow it, since the product is not completely clean, many times it has to be sold to someone else who is responsible for cleaning or selling it at a lower price to compensate for the part that the bean is missing.

Therefore, creating a system that can perform this process is a great advantage and helps all those who are dedicated to growing beans or some other seed. The implementation of a cleaning prototype that guarantees and commits to delivering a higher quality product is very satisfactory, because the cleaning process will take less time, preventing the raw material from passing to other people responsible for this process, reducing costs and obtaining more profits for the farmers.

Self-consumption and healthier eating with organic products (Sierra, 2014) is generating an area of opportunity in which prototypes are of great importance. This is because crops are in smaller quantities since they are expected to be only for self-consumption of the family or population (Agricultura ecológica, 2019), (San Martín granja integral, 2019).

Development

In this prototype, it is desired to carry out the cleaning of the bean with moving sieves. As the bean moves and falls from one sieve to another, the impurities that it could have fall to another part of the process to be separated. The clean and selected bean according to size continues with the cleaning process until it reaches a conveyor belt, where it can be packaged later or be subjected to a final visual check to ensure that the product is clean.

Currently there are machines responsible for this type of cleaning; however, it is intended to develop a prototype that is functional for the small and medium farmer, improving the manual method that we all know, which only consists of separating the stones from the beans.

Prototype procedure and operation

Bean cleaning consists in the total or partial elimination of impurities, to facilitate its conservation during storage, which is the objective of this prototype.

The separation of impurities is based on the differences between the physical properties of the bean and the impurities. When these properties are similar or identical, the separation becomes difficult; a clear example is when the stones are the same size as the beans.

In this case, whenever possible, the separation should be based on the property the difference of which is most marked.

The bean has three dimensions as shown in Figure 1. The 3 dimensions of the bean are: length, width and thickness. In cleaning machines, only the length and thickness dimensions are used to perform the separation.

Figure 1 Bean Dimensions
Source: Grain cleaning (FAO 2019)

To carry out bean separation it is necessary to determine which method is more convenient.

Separation depending on the width: To separate the beans of the same width, a round hole shank can be used, considering that the beans have the same length and thickness. Figure 2 shows this type of separation.

Figure 2 Separation based on width
Source: Grain cleaning (FAO 2019)

Separation depending on thickness. Grains that have different thicknesses can be separated with a mesh of elongated or oblong holes, if they are the same length and width. An example of this separation is shown in Figure 3.

Figure 3 Separation based on thickness
Source: Grain cleaning (FAO 2019)

Once the separation method to be implemented is determined, it is necessary to choose the type of perforation of the meshes used as screeners in the cleaning prototype, which is related to the shape of the product. According to the type of grains and impurities, it is necessary to choose a mesh appropriate to the shape of the product. An example of how the mesh separates the impurities is shown in Figure 4.

Figure 4 Cleaning mesh
Source: Grain cleaning (FAO 2019)

On this occasion it was decided to use oblong holes which are generally used in the separation of materials in which the elongated shape predominates, so they are mainly used to separate the grains according to their thickness. The oblong holes are specified by taking the width dimension and the hole length dimension. They are usually installed with the longer axis of the hole in the direction of grain movement, since separation is thus facilitated.

Another point to consider was the vibration system used to oscillate the screenings, so that the product comes into contact with the holes, making separation easier, and slides on the screens. The vibration system must have devices capable of modifying the amplitude and frequency of the oscillating movements, so that the mass of grains, with shapes and sizes other than spherical, will remain with the longitudinal axes of the grains perpendicular to the surface. In this way, when oscillating with precise movements, it will allow the grains to pass through the holes. Having these points already, we proceed with the design of the structure.

First, the part of the structure that would support the screens and the hopper was assembled, as well as the circuit part.

Figure 5 shows the part of the structure in which some planks were drilled to adapt the screen meshes. The back of the structure was left to put a board where the circuit would go.

Figure 5 Wood structure
Source: Prepared by the authors (2019)

Then, the conveyor belt that would be placed at the end of the last screening mesh was constructed. Figure 6 shows the band that has two axes which execute the action of the rollers, the axes are made of endless screws, which are attached to steel plates and bolted with nuts. At one end of the belt a motor was fixed, which transmits the movement towards the axis causing both to keep rotating through the conveyor belt. The conveyor belt is made of canvas. Presence sensors were placed in the band, which will keep it in operation when it detects the bean or make it stop when it no longer detects the presence of beans in the band.

Figure 6 Conveyor belt
Source: Prepared by the authors (2019)

Two presence sensors were placed: one at the beginning of the conveyor belt and the other at the end of the belt. The first sensor will make the band work whenever it detects the beans and the second sensor will deactivate it if there are no longer any beans in the band.

Two servomotors and two vibrating motors were also placed. One of the servomotors was used in the hopper to manipulate a connecting rod system which makes it open the hopper lid. And the other servomotor is in the band to transmit the movement between the axes. The vibrating motors were located in the screening meshes, so that they can move the mesh and thus the bean cleaning process is carried out as the route is implemented on the mesh. Figure 7 shows where these components are located.

Figure 7 Location of components
Source: Prepared by the authors (2019)

The operation of the prototype consists of depositing the bean in the hopper and by pressing the power button the hopper gate will open and the bean will fall on the first screening mesh, where the movement of the vibrating motors will perform the cleaning.

The function of this section is to separate the impurities which are larger than the beans in the mesh so that the beans fall to the next screening mesh, where the smaller soil and stones of the beans will separate as they move.

The clean beans will continue until they reach the conveyor belt, where sensor 1 is activated to keep the belt moving, until they fall into the container or packaging bag; if sensor 2 does not detect beans in the band, it will indicate to the band Stop working. Figure 8 shows the general structure of the prototype.

Figure 8 General structure of the prototype
Source: Prepared by the authors (2019)

The purpose of this system is to make the bean pass through screening sections where it is cleaned of impurities, so that it is as clean as possible.

Programming Operation

This project was developed in CUPL language, using its free compiler called AWINCUP which was supplied by Atmel. The CULP language is a universal compiler for various programmable logic systems, among them is GAL (Generic Array Logic). In this specific case, we use the GAL16v8.

Below is the programming used for our bean cleaner, which includes the header, pin declaration and processing commands or functions, where we can see the 3 main parts of the program such as configuration, declaration of inputs/outputs and logical functions.

Name Limpado de frijol;
PartNo 00;
Date 07/11/2018;
Revision 01;
Designer EQUIPO;
Company HP;
Assembly None;
Location
Device g16v8;

```
/* *****  
*****/  
PIN      2 = Botón puerta          ; /*  
*/  
PIN      3 = Sensor1                ; /*  
PIN      4 = Sensor2                ; /*  
PIN      5 = Botón encendido        ; /*  
*/  
PIN      6 = x                      ; /*  
*/
```

```
/* *****  
*****/  
PIN      12 = Motor puerta          ; /*  
*/  
PIN      13 = Motor banda           ; /*  
*/  
PIN      14 = Vibradores            ; /*  
*/  
PIN      15 = Luz encendido         ; /*  
*/  
PIN      16 = Luz espera             ; /*  
*/  
PIN      17 = Luz apagado           ; /*  
*/  
PIN      18 = y                      ; /*  
PIN      19 = z                      ; /*  
*/
```

```
Luz encendido= Botón encendido;  
Luz espera=! Botón puerta & Botón encendido;  
Luz apagado=!Botón encendido;  
Motor puerta= Botón encendido & Botón puerta;  
Vibradores= Botón encendido;  
Motor banda= Botón encendido& (Sensor1#Sensor2);  
PIN      2 = Botón puerta          ; /*  
*/  
PIN      3 = Sensor1                ; /*  
PIN      4 = Sensor2                ; /*  
PIN      5 = Botón encendido        ; /*  
*/
```

Within the code, the input variables were declared: the gate button that controls the hopper opening; the power button where the motors and indicators are activated so it also influences the operation of the conveyor belt; the sensor 1 and sensor 2 which are presence sensors that will activate the band when they detect beans in the band and will stop working when it does not detect them.

From the programming the connection circuit was made. Figure 9 shows the connection circuit.

Figure 9 Connection diagram
Source: Prepared by the authors (2019)

Methodology to develop

This project developed from the need of small bean farmers in the northern area of Nayarit, the home region of one member of the team. The Peruvian bean was used as a reference for the validity of the prototype.

Results

Finally, the prototype carried out the main objective which is to clean the beans. This action was possible, since after the screening process there was a final product approximately 95% clean of the impurities that it presented. However, certain details emerged such as not all beans can be cleaned because there are only two screening processes, and due to the selection of the holes in the cleaning mesh.

For portions of 1 kg of beans, the prototype performs the cleaning in an approximate time of 3 minutes, having a cleaning quality of up to 95%. As mentioned earlier it was a process with two screening stages and a specific type of hole, just making a bean separation considered first.

The proposed prototype is exclusive for the cleaning of Peruvian beans, this is determined by the type and hole size of the mesh that performs the cleaning. If we want to change beans, it is necessary to determine the size and shape of the mesh hole.

With the aforementioned, it can be said that this prototype will provide added value to bean crops of small farmers in the northern part of the state of Nayarit.

Discussion

The cleaning of agricultural products is a practice adopted thousands of years ago and little has changed since then, because nowadays the same mechanical principles are used. In rural areas, cleaning systems are quite rudimentary, usually employing manual sifters.

Therefore, a system to reduce this effort, making more efficient the process and giving added value to the final product is of great help to small bean producers. Taking the above, it can be said that the prototype meets the main objective.

It is important to consider that commercial brands already exist, for example zaccaria who offer better benefits than the prototype presented in this work (Zaccaria, 2019); but for the small farmer to consider the expense of a machinery with industrial characteristics is very complicated, and the prototype described in this document is viable to be acquired and implemented in the small farmer cleaning process. In addition to the aforementioned company, we can mention hegamedex, Labtronic, Hydropure, Grupogaurel, among others, that make this type of machinery for the industrial sector with very similar characteristics as the zaccaria company.

The National Polytechnic Institute carried out the design and construction of a machine to screen bean seeds, (Almanza, 2010) which consists of a single screening trap having a process on which it bases its cleaning of the product for the time it takes to circulate the bean. In the case of the prototype described in this document, it consists of two stages and therefore the time is reduced by consuming less electrical energy and therefore being more efficient. In a similar protocol as a classification of corn (Washinton & Rolando, 2013) and a prototype of a bike-blender (Varas, 2018), both are intended to solve a need in a particular social environment, an intention that this paper also shares.

In the process of other grains such as rice, it is implemented through bulldozers with holes in the mesh according to the standard that is required to be cleaned (Agroindustrial Study and Design, 2016); in the case of the bean cleaning prototype, the same principle applies and we remark that its advantage with respect to these products is the cost of the machinery (Rios & B., 2009).

Conclusions

In the Bean Clean prototype, the bean cleaning is carried out but in a different way from what already exists; in particular this prototype is only for the Peruvian bean since the measures for the meshes were taken of a sample of this type of grain. We have the limitation of the type of bean that is used, since the sizes that each one has are different.

A projection is to make the Bean Clean have the ability to clean more types of beans, adapting it so that each type can have an exit preventing them from mixing with each other.

The benefit to society could be that the cost of beans would be lower since it was not necessary to pay a company for doing the cleaning procedure. Also, if the consumers gain a lower price, they would stop looking for the beans that are sold without cleaning and would save time in doing the process manually.

Even with the corrected details, such as the size of the spaces through which the bean passes in the first and second screening mesh, the prototype is functional and allows us to carry out our task without any problem.

However, a disadvantage in comparison to other cleaning systems, it cannot clean any type of bean and does not have more screening meshes. Other systems also work to select beans that can be considered top-tier, a situation that cannot occur in its entirety in this prototype.

Disregarding the possible disadvantages, this prototype could be implemented on a larger scale and its investment cost could be less than what other equipments cost. Finally, we made a prototype capable of cleaning the beans which was our objective, along with clearly explaining the results obtained and the possibilities for improvement.

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