Universidad Continental

FACULTAD DE INGENIERÍA

Escuela Académico Profesional de Ingeniería Mecánica

Tesis

Design and manufacturing of a potato sorting machine for the blanca Yungay variety in the Junin region-Peru

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Desing and Manufacturing of a Potato Sorting Machine for the Blanca Yungay Variety in the Junín Region - Perú

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***ABSTRACT*— This project is aimed at the agricultural sector, especially small and medium-sized tuber traders. Worldwide Peru ranks as the fourteenth producer of the Andean tuber, where potato production is the highest contributor to the economy of the agricultural sector due to the intense activity of about 330 thousand hectares of cultivation, distributed in 19 regions having the Junín Region as one of the largest contributors in the production of this tuber. For the marketing of the potato the most important part is its classification. That's why it has to be catalogued according to its dimensional and quality characteristics to establish a certain price for the product. That's why we designed a machine that performs the function of sorting by size in a much shorter time to minimize the labor employed. The prototype was designed through the fulfillment of a list of requirements and structure of functions divided within a morphological matrix in order to find various solution concepts, which were evaluated technically and economically for the ideal choice of the final prototype.**

The design was carried out through simulations carried out with the SolidWorks Simulation CAD software and through mathematical calculations, it was possible to obtain a machine that classifies 50 kg of potato in an interval of 1 to 2 min. The prototype has manual operation through a crank-crank connecting rod system, it also has as an option the installation of an internal combustion engine for the operation of the sorting screen.

Keywords- Potato sorter, Andean tuber, Ycungay white variety, machine design, prototype.

I. Introduction

Potato sowing in Peru was carried out 7000 years ago based on archaeological research of pre-Inca cultures. The cultivation in Europe dates back to the end of the sixteenth century after the conquest of Peru, giving rise to the contribution of a new food from South America to Europe [1].

The potato is considered as the fourth most consumed and produced food in the world, this is because its global production exceeds 320 tons per year, it's estimated that this tuber is present on the table of more than a hundred countries between Latin America, North America, Africa, Asia and Europe [2]. According to studies there are more than 4000 varieties of potato in the world which shows that this is a tuber that has a great genetic diversity. Its production occurs in the Andean regions since the producers assure that these regions are the most suitable due to their climatic conditions, altitude and the richness of the soils [3].

The potato is largely consumed for its nutritional value compared to other tubers. Variations in its size, shape, color and texture can give rise to various forms of consumption and different ways of preparation as part of food [4]. That's why it is extremely important that agricultural producers classify this product mechanically into 3 different categories where we find the first potatoes, second potatoes and third potatoes.

According to the International Potato Council (IPC), production in Peru should focus on improving the competitiveness chain mainly for medium and small farmers in order to gain commercial advantage within the national market, which is why they seek to encourage the modernization of production with innovations that promote the improvement of the productive chain [5]. In Peru the potato production is not homogeneous, we find different varieties that are cultivated, but at the same time three potato market sections are identified among which we have the yellow, native and white potatoes [6]. The need is created to improve small businesses and medium-sized producers, innovating their pre-sales processes and thus facilitating a sustainable negotiation with a resilient infrastructure that facilitates competitive trade. With innovations, farmers improve their incomes, thus following the guidelines established by the Sustainable Development Goals, giving a fundamental approach to SDG 9 that establishes and promotes the implementation of an inclusive, sustainable

industry, with new technology, easy trade and efficient use of natural resources [7].

In the last two years the world went through an economic crisis that also affected Peru, that's why the need to establish a resilient infrastructure in each production process is established, not only in agriculture but also in the various economic activities that sustain the country. The World Bank assesses that each developing country needs to invest an average of 4.5% of GDP to achieve the goal of achieving the Sustainable Development Goals by 2030 [8].

The present research seeks to contribute to the scope of SDG 9 by creating a potato sorting machine that helps in the marketing of small and medium farmers in the Mataro Valley of the Junín region of Peru.

II. Materials and Methods

The present project developed the methodology adapted to the VDI 2221, which focuses its activities on the search for solutions in order to obtain accurate information in order to develop a prototype that meets all the requirements established precisely [9].

In Figure 1 we visualize the methodology that we developed the present project by analyzing the problem, choosing the solution concept, design, manufacturing and validation according to the demands and needs that the farmer of the Junín Region requires.

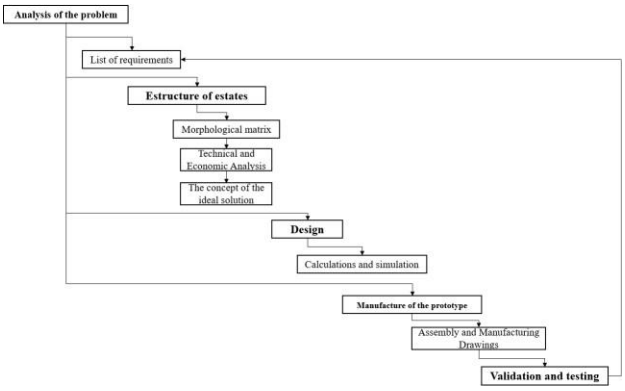

Fig. 1. Adapted design methodology.

5 solution concepts were made and for the choice of one of them it was evaluated in a technical and economic way.

Table I details the results obtained according to the weight given to each type of technical and economic evaluation.

TABLE I. DETERMINATION OF THE OPTIMAL SOLUTION

Designs	Technical valuation index	Index of economic valorization
Design 1	0.72	0.62
Design 2	0.74	0.56
Design 3	0.67	0.48
Design 4	0.63	0.77
Design 5	0.96	0.95

The solution concept that met the most characteristics of the technical and economic criteria was the solution concept 5 with a technical valorization index of 0.96 and economic valorization index of 0.95. It consists of a pyramidal hopper that will have the function of receiving the potato for its classified, the crank connecting rod mechanism will be in charge of giving drive to the whole machine who will generate vibratory movement in the 3 trays that are located with an inclination for a quick classified, each tray has an appropriate hole dimension for each type of potato and a gutter for its final extraction.

III. Results

According to the regional agrarian directorate, the potato is classified into up to five categories according to the dimensions that each one possesses, but the most common and commercial categories are three, the so-called first, second and third potatoes [10].

The Ministry of agrarian development and irrigation estimates that more than 711,000 people are dedicated to potato production, among all the potato varieties that exist in Peru the best known for their marketing and production are the Yungay, Canchan and Peruanita white potatoes [11].

For the manual selection of the potato by size for the amount of 3 moles equivalent to 21000 kg of potato, 9 people are required to work 8 hours, reaching a total of 72 hours of work performed by all the pawns. [12]. The approximate economic remuneration that each person receives is estimated at 11.72 USD, having a total labor cost of 105.5 USD per day [13].

With the help of measuring instruments and taking 4 specimens of each potato size we find the dimensions such as the length, width and average weight of the first, second and third potatoes which we can see in Table II.

TABLE II. DIMENSIONES Y PESOS DE LA PAPA EN LA VARIEDAD BLANCA YUNGAY

Classification by size	Dimensions		
First-class pope	Long (mm)	Width (mm)	Weight (Kg)
Average	105.39	99.22	0.303
The second pope	Long (mm)	Width (mm)	Weight (Kg)
Average	78.20	72.63	0.201
The third pope	Long (mm)	Width (mm)	Weight (Kg)
Average	56.49	53.61	0.097

From the averages of the dimensions found we elaborate the trays that will oversee distributing the potatoes for their

classification.

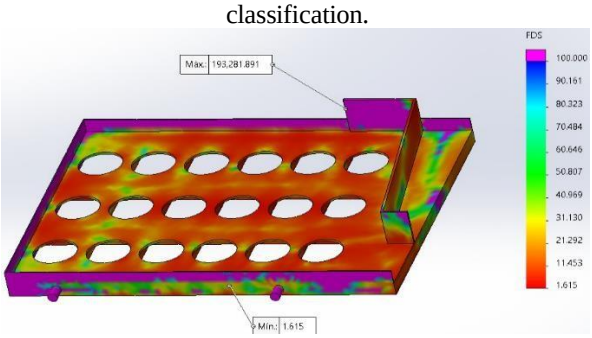

Fig. 2. Safety factor simulation of the tray 1.

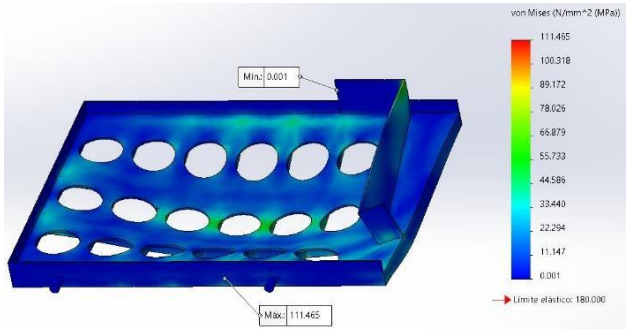

Fig. 3. Tray tension simulation 1.

The tray 1 is intended for sorting potato of about 10.6 cm in diameter with an average weight of 0.303 kg according to Table II. Being in charge of receiving the potato from the feeding hopper from the top and from one of the sides the first potato comes out through the extraction channel of the tray 1. In Figure 2 through the simulation with the SolidWorks simulation program we obtained a safety factor of 1.615 coming from the elastic limit of 180 MPa (SAE1010), in Figure 3 we visualize the maximum effort by the external load which is 111.465 MPa for a plate thickness of 1.5 mm

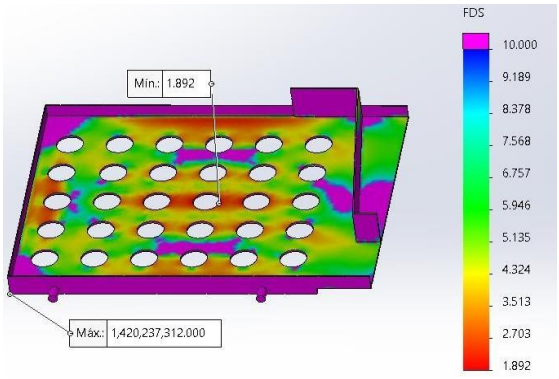

Fig. 4. Tray safety factor simulation 2.

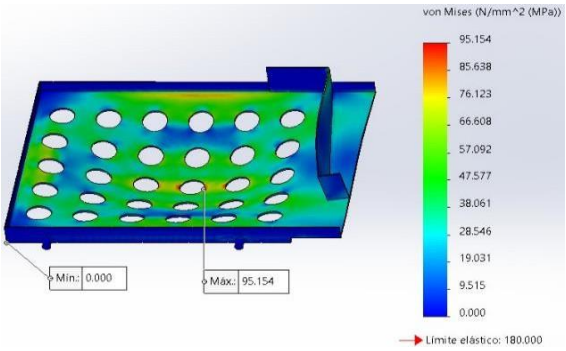

Fig. 5. Tray tension simulation 2.

The tray 2 is intended for sorting potato of about 7.9 cm in diameter with an average weight of 0.201 kg according to Table II. Receives the potato that falls from tray 1 and extracts the second potato through the extraction channel of tray 2. In Figure 4 through the simulation with the SolidWorks simulation program we obtained a safety factor of 1.892 coming from the elastic limit of 180 MPa (SAE1010), in Figure 5 we visualize the maximum stress by the external load which is 95.154 MPa for a plate thickness of 1.5 mm.

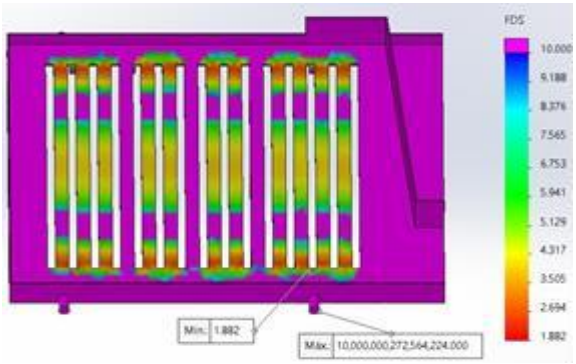

Fig. 6. Safety factor simulation of the tray 3.

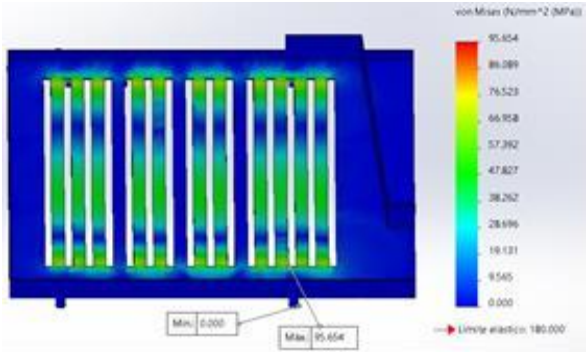

Fig. 7. Tray tension simulation 3.

The tray 3 is intended for the reception of the potato of about 5.7 cm in diameter with an average weight of 0.097 kg according to Table II. The remaining potato called third potato is extracted by the tray extraction channel 3. In Figure 6 through the simulation with the SolidWorks simulation program we obtained a safety factor of 1.882 coming from the elastic limit of 180 MPa (SAE1010), in Figure 7 we visualize the maximum

stress by the external load which is 95.654 MPa for a plate thickness of 1.5 mm.

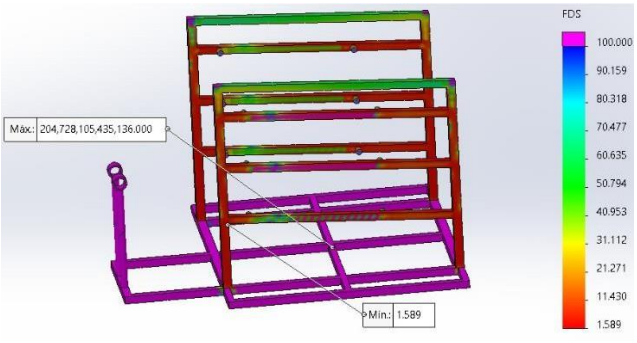

Fig. 8. Safety factor simulation of the structural base.

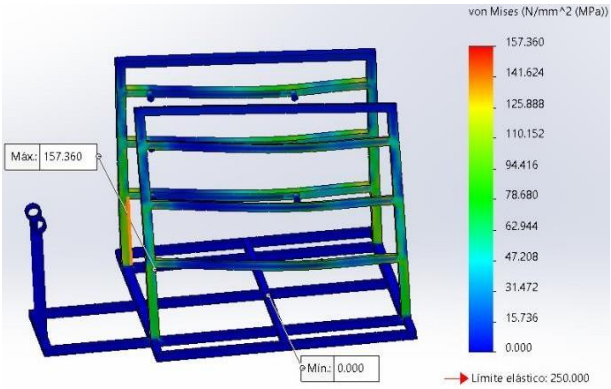

Fig. 9. Safety factor simulation of the tray 3.

The structural base is responsible for supporting all the elements and movements of the machine. In Figure 8 through the simulation with the SolidWorks simulation program we obtained a safety factor of 1.589 coming from the elastic limit of 250 MPa (A36), in Figure 9 we visualize the maximum stress by the external load which is 157.36 Mpa for a 1-inch square tube.

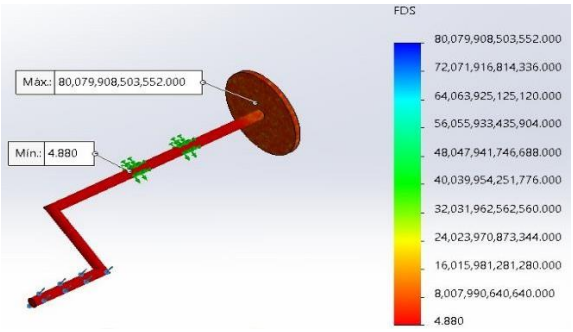

Fig. 10. Safety factor simulation of the machine drive system.

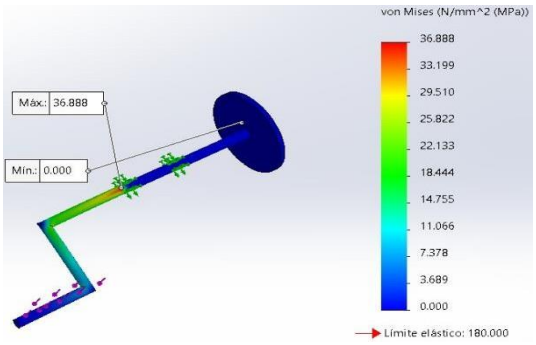

Fig. 11. Tension simulation of the machine drive system.

The operation of the machine will be mainly carried out by a connecting rod-crank mechanism that will transform the movement that we will exert on the steering wheel to a circular movement to subsequently give operation to the sifting system. In Figure 10 through the simulation with the SolidWorks simulation program we obtained a safety factor of 4.88 coming from the elastic limit of 180 MPa (SAE1010), in Figure 11 we visualize the maximum effort by the external load which is 36.888 MPa for an axis of ½ in.

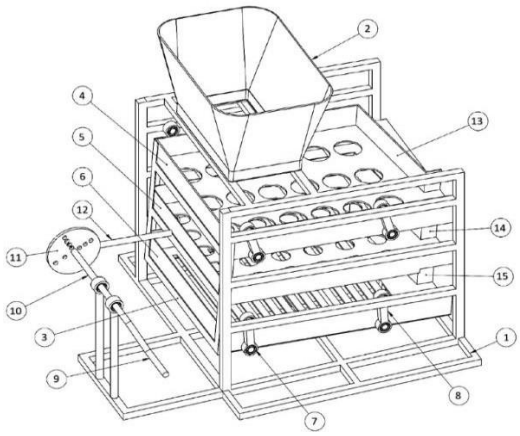

Fig. 12. Design of the final prototype.

Fig. 13. Manufacture of the prototype.

The components indicated in Figure 12 are displayed in Table III, together with their description and the number of elements that make up the machine.

TABLE III. LIST OF COMPONENTS

N°	Components	Description	Cantidad
1	Structural basis	Supports all the elements of the machine.	1
2	Pyramidal hopper	Dose the income of the potato.	1
3	Frame of the trays	Tray support, has an inclination on the tray seat in the direction of the extraction channels.	1
4	Tray 1	To classify the potato first.	1
5	Tray 2	To rank second dad.	1
6	Tray 3	To classify potato of third and the impurities that will leave each type of potato.	1
7	Bearing	Connection with a degree of freedom between the swing arm and the frame of the trays.	19
8	Swing arm	It allows the oscillating movement of the frame of the trays.	8
9	Crank	For the generation of the rotational movement.	1
10	Main axis	It transmits the movement to the disk with eccentric holes.	1
11	Disc with eccentric holes	Regulates the oscillation amplitude for the frame of the trays.	1
12	Transmission bar	It gives oscillating movement to the trays.	1
13	Extraction channel of the first tray	First-class potato extraction guide.	1
14	Extraction channel of the second tray	Second-rate potato extraction guide.	1
15	Extraction channel of the third tray	Third-rate potato extraction guide.	1

TABLE IV. DETERMINATION OF THE IDEAL SPEED

Experiments	Amount of potato (kg)	Speed (rpm)	Time (minutes)
Experiment 1	50	27	2
Experiment 2	50	32	1.57
Experiment 3	50	37	1.51
Experiment 4	50	42	1.45
Experiment 5	50	47	1.4
Experiment 6	50	52	1.3
Experiment 7	50	57	1.33
Experiment 8	50	62	1.37
Experiment 9	50	67	1.42
Experiment 10	50	72	1.46
Experiment 11	50	77	1.49
Experiment 12	50	82	1.53
Experiment 13	50	87	1.56
Experiment 14	50	92	1.59
Experiment 15	50	97	2.01

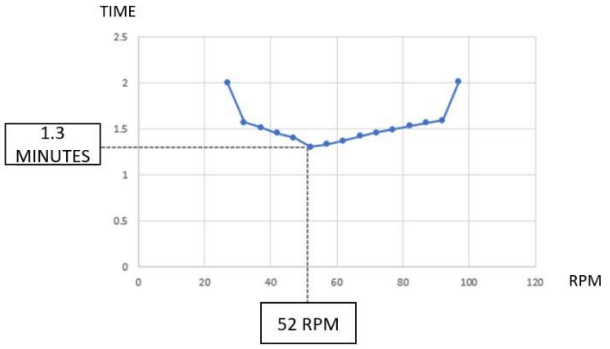

Fig. 14. Diagram of the ideal time in RPM.

To determine the ideal speed at which the machine should work, we carried out a series of experiments detailed in Table IV, where through a diagram shown in Figure 14 we can affirm that said speed is 52 revolutions per minute with a minimum process time of 1.3 minutes. With these parameters we get the highest production.

Fig. 15. Amplitude of the zaranda system.

The screen amplitude can be regulated by a disc of eccentric holes with distances between them of 1.5, 2, 2.5 and 3.5 cm. For the tests conducted and shown in Table IV, the tests were worked for an amplitude of 2cm, which we can see in Figure 15.

IV.Conclusions

The present prototype consists of an appropriate technology in terms of the drive, commercial elements of which it is composed, easy maintenance, ergonomic system for the operator and the most outstanding thing is that it has dimensions of easy transfer for rural areas in which it will perform.

The quality of the product that the machine will deliver is good because the trays have a separation distance of 20cm with an inclination angle of 15º and were made of a SAE1010 material thus guaranteeing that the potato won't be exposed to any type of damage.

The machine has a high efficiency in its classification by means of trays driven in the form of vibration with a sifting amplitude adjustable by a disc with eccentric holes that will regulate the amplitude of travel of the trays

For future work such as minimizing the risk of injury to the operator, it is recommended to design a pedal-operated drive system. Also perform trials by swapping the trays for other varieties of potatoes by shape and size. Finally, perform tests to find the optimal speed for other amplitudes of the disc with eccentric holes.

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