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Research paper

Design and development of cocoa pod breaking and beans extraction machine

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Abstract

The cocoa bean damage is one of the main problems of pod breaking process. Beans damage, separation of beans from mixtures and scrap shells are the main problems related to cocoa pod breaking. The objective of this work is to determine the physical and mechanical properties of cocoa pods required for the design of the equipment, dimension of the different parts constituting the equipment and put in place a geometric representation of the equipment that can rise the quality of cocoa products. Some physical and mechanical properties of the pod where obtained through experimental study. Different varieties of cocoa were initially subjected to compressive forces along the lateral axis. After that, they were set on a test bench to break the pods one after the other with a mass of steel at different heights. Thus, the average breaking strength and the moisture contents of each variety of cocoa pods were determined. This fracture resistance of the cocoa pod was measured in terms of average force, deformation and toughness at the cocoa shell fracture, and cocoa pod stiffness (rigidity). The modulus of rigidity of the pod was obtained from measurements of force and deformation. From the physical and mechanical properties of the pod, we modelled a suitable machine. This designed machine severs the poles and ruptures the pods facilitating extraction of the beans on the hulls. It can be assembled and disassembled easily, reliably and without any risk for the user. Consequently, it might be used by all cocoa producers in other to optimize the process of cocoa pod breaking.

Keywords: *Design; Development; Cocoa Pods; Extraction; Beans; Machine.*

1. Introduction

Cocoa is widely produced throughout different continents in the world namely Central and West Africa (especially Cameroon), Latin America and Asia. Cocoa pod is a composite material constituted of an external part, the shell, the placenta and the seeds. The principal utilization and economic importance of cocoa lies in medications and production of products such as chocolate, oil, petrol, candles, etc. [1]. Cocoa farmers face problems of productivity that contribute to the reduction of their reduction of profits due to the inadequacy (inaccurate) of tools and technical methods applied during valorization agricultural product. After harvesting of cocoa pod breaking is the first process. Todays, and in many production zones, this process is carried out manually with machete or wood on each cocoa pod. It is dangerous, nonproductive and sometimes cocoa seeds are destroyed or cut. Since the rupture force is not well assessed, modelling of this force is relevant for designers of cocoa pod breakers. Mechanical parameters can be determined through a quantitative analysis of cocoa pod. Findings have in that the objective of the cocoa pod breaking process is to extract cocoa seeds from placenta. Compressive, shearing and impact the force are needed for that purpose according to machine design technology and process [2-4]. Compression testing of cocoa pods gives objective method to determine mechanical proprieties that permit to assess the minimal allowable load to break cocoa pods without destroying seeds. In large farms, mechanical scabbing machines are used but some beans are damaged and also the separation of the cocoa bean-shell mixture is not optimal. Cocoa, one of the most coveted raw materials, is a real competitiveness challenge through its production, import and export. The process of scrapping on a Cameroonian scale is still artisanal. But the main challenge of competitiveness for cocoa products or derivatives is the quality of the beans. This is particularly evident cocoa farms where operations for dried beans production are usually manual and rudimentary. Given all the advantages of Cocoa, the production and processing of cocoa must be mechanized in order to improve the quality of cocoa production and processing by reducing losses and thereby increasing profits. It comes from the above, the need to analyze the breaking force of cocoa pods, to carry out a modeling of the design and to size an equipment that can crush and make an optimal separation of the beans from the debris of Cocoa shells. This equipment is designed to respect market requirements being accessible to the farmers of Cocoa in the world. Conclusions will be draw from the study and possible perspectives in order to improve and develop modeling of this technique of scrambling.

2. Literature review

Visits were made to the cocoa plantations, requiring the way the farmers manually scoop using machetes, clubs and knives. Research has already been carried out to this work, where researchers have discovered machines. This work has been done so far in the field of the mechanical scabbling process [5-6]. In this regard, it has been found that other researchers have come up with machines that can process the cocoa [7-9]. Experiments were conducted to determine the extent to which broken pieces of cocoa and cocoa beans that mix during breaking can be separated [10]. Documentary sources show that there was a cocoa crusher designed, manufactured, tested and operated by hand. This machine is used by cocoa farmers located in rural areas where there is no source of electrical power. It has been argued that ecoshooting is a process to extract the seeds from the pod and the forces involved in breaking the cocoa pods could be compression, impact or shear forces depending on the type of machine and process [2-4]. [7] reports that the first ever cocoa pod breaking machine in Nigeria was built at the Nigeria Cocoa Research Institute (INRC). A similar machine built by the British company Messers Christy and Norris was tested at the Cadbury brothers' cocoa plantation in Ikiliwindi, Cameroon [8]. The operating principle and mechanism to these machines requires two people indispensable; one feeds the machine into cocoa pods while the other collects the beans. The nacelle must be broken through a vertically mounted rotating wooden rib cone inside a cylindrical drum with metal ribs. The pods introduced into the hopper pass to the gravity bombardment section. The seeds pass through the meshes in a collection wooden box, while the shell or shell fragments are left at the open end of the rotating sieve [11-13]. Another model called the Zinke machine was designed and tested by [9]. This machine model uses several toothed jaws or rotating cylinders. This machine consists of a hopper, a meter plate, a hammer and vibrating sieve. The hammer breaks the pods while the vibrating sieve separates the hull. The beans are collected by the evacuation chute. The latter also had the problem of crushing shells in smaller portions which mixes with moist cocoa beans which poses a problem during separation. A machine for shearing cocoa pods on their intermediate diameter longitudinally has been developed by [14]. This machine shears the pod and leaves the cocoa beans attached to the placenta of the shells. The average forces obtained from the hertz's theory for breaking cocoa pods were 609.66 N, 740.55 N, 504.59 N, respectively for "Criollo", "Forastero" and "Trinitario", according to [15]. [4] Design, manufacture and test a type of hand-operated machine to break cocoa pods. The machine has been designed to be capable of cutting at most five (05) of the pods and consists of an average number of hammers capable of breaking the pod, a screen for separation, a chute for lowering cocoa beans. This model shown below also had the problem of crushed cocoa shells mixing with moist beans. In spite of this, these machines mentioned above cannot achieve the desired objectives and results as expected for cocoa crushing machines, and the world on harvesting and processing very essential agricultural products still remains a big problem and a challenge [16-17].

3. Materials and methods

3.1. Sample preparation

Pods samples of three varieties of cocoa grown in the Centre region of Cameroon were harvested and kept to ripe of seven days, then broken manually and beans extract. For each of the varieties shown in Figure 1, different sizes of ripe cocoa pods were selected for the study.

Fig. 1: Different Varieties of the Cocoa Pod: (A) Criollo, (B) Forastero and (C) Trinitario.

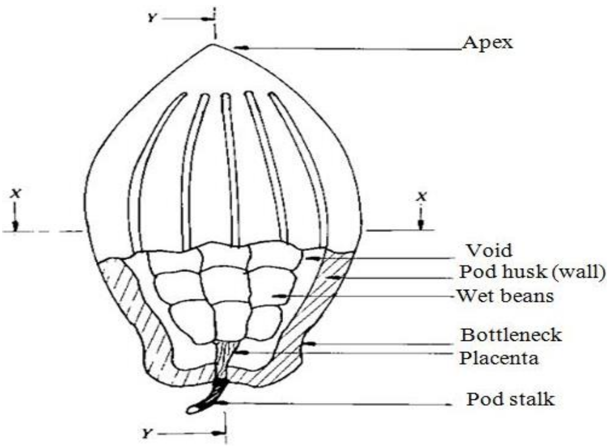

Fig. 2: A Longitudinal Half-Section of a Whole Cocoa Pod Showing Wet Beans. X-X A Lateral Cross-Section; Y-Y Longitudinal Section [18].

3.2. Test equipment and methodology

3.2.1. Determination of physical properties

Some physical assets considered in this study are the sizes and shapes. On each cocoa pod we measured three linear dimensions, that is length (a), intermediate diameter (b) and major diameter (c), using a Vernier calliper (ROCH-France) reading to 0.02 mm.
The geometric mean diameter (dg) was determined, and also the expression of sphericity (ϕ) of the pod was defined [19] from the main principal physical dimensions.

$$d_g = (abc)^{\frac{1}{3}} \quad (1)$$

$$\varphi = \left[\frac{bc}{a^2}\right]^{\frac{1}{3}} = \frac{(abc)^{\frac{1}{3}}}{a} \quad (2)$$

We were capable to obtain the physical dimensions of cocoa beans from the expression in section 3.2. The arithmetic mean diameter (d_a) was determined from the main principal physical dimensions.

$$d_a = \left(\frac{a+b+c}{3}\right) \quad (3)$$

For the ratio aspect of the cocoa beans, the samples were also selected at random for conducting the experiment. Measurements of all size and shape indices were replicated five times to give more relieve average. The ratio aspect (R_a) was calculated, according to [20] as:

$$R_a = \frac{b}{a} \times 100 \quad (4)$$

The flat surface area, transverse surface area and volume of the cocoa beans were calculated, according to [21].

$$A_f = \frac{\pi}{4}(ab) \quad (5)$$

$$A_t = \frac{\pi}{4}(bc) \quad (6)$$

$$V = \frac{\pi}{6}(abc) \quad (7)$$

3.2.2. Determination of pod cocoa pod and beans mass

The mass of each varieties cocoa pod "Criollo", "Forastero" and "Trinitario" were determined by using an electronic balance (KERN 440-45N) to an accuracy of 0.1 g. measurements were repeated 20 times each.

3.2.3. Determination of cocoa bean density

The density of the cocoa beans was determined by water displacement technique [22]. The cocoa pods ripe were randomly selected, break and opened to separate the beans and the husk. The beans and the broken pieces of the husk were weighed separately to determine their masses (m), and then lowered into a graduated measuring cylinder containing 1000 ml of water. The fruit was submerged during immersion in water. The net volumetric water displacement (V) of the samples of the beans and husk were determined. The densities (ρ_b) of the respective samples were determined using equation below:

$$\rho_b = \frac{m}{V} \quad (8)$$

3.2.3. Sliding friction characteristics

The static angle of repose (ϴ) was determined using two plates, one fixed and the other adjustable. Two suitable materials such as stainless steel and carpet (polystyrene) were used for the determination the static coefficient friction the shells. The adjustable plate was covered with the suitable material and the sample placed on it and the adjustable plate was gradually inclined until the sample began to slide. Each measurement was performed in five times for each of the surfaces. The static coefficient of friction was calculated according to [23] as follows:

$$\mu_s = \tan\theta = \frac{h}{x} \quad (9)$$

Where x = horizontal base of the plane and h stands for height of inclined plane at point of slide.

3.2.4. Compression test of cocoa pods between two rigid plates

Different samples of the three cocoa varieties were subjected to compression tests. Each pod compressed between two parallel steel plates using a universal testing machine GUNT HAMBURG (model 198079) as shown in Figure 3. Compression force was applied progressively until the pod completely broke, ant this experiment was repeated many times on the different sizes and varieties of cocoa pods. The test force was measured using a hydraulic force measuring device. After breaking of pod, moisture content of the husk was obtained using the oven method [24], where each of the different varieties were placed in oven at 105°C for 24 hours.

Fig. 3: Experimental Device Universal Testing GUNT HAMBURG (Model 198079) Used for Compressibility [15].

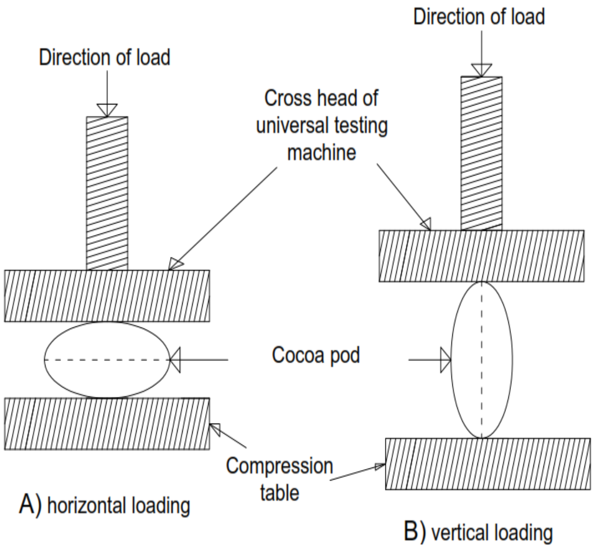

Fig. 4: Orientations of Cocoa Pod During Quasi-Static Compression Tests.

3.2.5. Drop-weight experiment

Cocoa pods different varieties were taken from a similar lot for which the physical properties were determined. A test rig was settled to drop a solid mass of 2.5 Kg from different heights to break pods one by one. The heights from which pod successfully broke were recorded. [25] Has shown that, for a load W in Newton (N), dropping at a certain height h in meters (m) on top of a body with a material stiffness S in Newton/meter (Nm-1), the equivalent impact force F in N is given by the expression:

$$F = W\left[1 + \sqrt{1 + \frac{2Sh}{W}}\right] \quad (10)$$

4. Results and discussion

4.1. Physical properties

4.1.1. Geometric characteristics of cocoa pods

Table 1 shows the average values of physical dimensions of the cocoa pod varieties selected. The cocoa pods dimensions were not significantly different ($P \leq 0.05$) for all three varieties at given humidity. The average values of the length the pods were 167.14 mm ± 34.06, 154.25 mm ± 20.85, 159.81 mm ± 22.17 for "Criollo", "Forastero" and "Trinitario" and also the mean values of the equatorial diameter obtained from the experimental measures were for 89.46 mm ± 6.37, 90.88 mm ± 6.61, 88.70 mm ± 3.97 for "Criollo", "Forastero" and "Trinitario", respectively. The thickness averages of the husks furrow in the range of physical dimensions were evaluated from multiple thickness measurements. Statistical analysis shows on table 1 gave an overall average of the sphericity of 0.68 and also showed no significant difference with the different varieties of pods. The pods deviate from the spherical shape according to the values presented in table 1.

Table 1: Geometric Characteristics of Cocoa Pod of Variety

	Variety of the cocoa pod Criollo			Forastero			Trinitario		
Physical properties	Mean value	Min. value	Max. value	Mean value	Min. value	Max. value	Mean value	Min. value	Max. value
Axial dimensions, mm									
Length, a	167.14 (±34.06)a	134.40	248.10	154.25 (±20.85)a	129.70	192.60	159.81 (±22.17)a	132.20	196.70
Intermediate diameter, b	86.15 (±6.03)a	76.30	94.40	87.49 (±5.67)a	75.70	100.30	84.36 (±3.30)a	78.40	90.15
Equatorial diameter, c	89.46 (±6.37)a	78.70	97.90	90.88 (±6.61)a	77.00	108.30	88.70 (±3.97)a	81.80	95.50
Geometric mean diameter, dg	108.37 (±8.99)a	95.60	129.22	106.90 (±8.59)a	91.10	127.90	105.89 (±5.42)a	96.59	113.41
Sphéricity, ϕ	0.66 (±0.08)a	0.52	0.80	0.70 (±0.05)a	0.63	0.80	0,67 (±0.07)a	0.58	0.79
Arithmetic mean diameter, da	114.25 (±23.28)a	96.47	146.8	110.87 (±14.99)a	94.13	133.73	110.96 (±15.34)a	97.47	127.45
External thickness	12.96 (±1.05)a	11.40	14.30	14.58 (±0.88)b	13.30	16.30	13.63 (±1.81)ab	11.00	16.80
Internal thickness (furrow)	11.31 (±0.77)a	10.10	12.40	13.03 (±0.79)b	11.90	14.20	11.32 (±1.48)a	9.90	14.30
Mass of the cocoa pod, g	482.1 (±99.7)a	338.2	686.2	520.6 (±113.1)ab	340.4	797.5	564.6 (±116.9)b	437.6	781.4

Mean ± standard deviation; the means of the physical dimensions found on the same rows and carrying the same letter in the superscript are not significantly different at probability P<0.05.

4.1.2. Geometric characteristics of cocoa beans

A summary of the results of some physical properties of the cocoa beans determined in this study were shown in Table 2. The mean value of physical properties the cocoa beans was 25.50 mm ±1.88, 13.90 mm ±0.80 and 9.20 mm ±0.62, for length, width and thickness, respectively. Dimensions of cocoa beans exceed those for Jatropha Curcas seeds [26]. These dimensions may be useful in estimating the size of machine components. The cocoa beans sphericity and ratio were found to be 58.17% and 54.59%, respectively. The high sphericity of the cocoa beans is indicative of the tendency of the shape towards a sphere. Taken along with the high ratio aspect (which relates the fruit width to length), leading to the fact that palm fruit will rather roll than slide on their flat surfaces. However, the ratio aspect value is being close to the sphericity values may also mean the cocoa beans will undergo a combination of rolling and sliding action on their flat surfaces.

Table 2: Geometric Characteristic of Cocoa Beans

Physical properties	Unit of measurement	No. of observation	Mean value	Minimum value	Maximum value	Standard deviation
Length, L	mm	100	25.5	19.6	29.7	(±1.88)
Width, W	mm	100	13.90	11	15.9	(±0.80)
Thickness, T	mm	100	9.20	6.2	11.32	(±0.62)
Geometric mean diameter, dg	mm	100	14,80	11.41	16.14	(±0.67)
Arithmetic diameter, da	mm	100	16.22	13	18.04	(±0.77)
Sphericity, ϕ	%	100	58.17	51.73	71.93	(±3.88)
Aspect ratio, R	%	100	54.59	47.67	66.33	(±3.65)
Transverse surface area, At	mm^2	100	100.44	53.59	121.14	(±11.38)
Flat surface area, Af	mm^2	100	279,72	188.41	366.04	(±32.20)
Volume, V	mm^3	100	1709.74	778.07	2200.74	(±218.37)
Density	kg/m^3	100	874.52	680.39	1041.55	(±28.79)
Mass, m	G	100	2,46	1.8	2.5	(±0.13)

From the Mean Values of Table 2, the Equation Below Was Determined According to the Physical Properties of Cocoa Beans

$$L = 1.83W = 2.77T \quad (11)$$

The volume (V), flat surface area (Af), transverse surface area (At), geometric mean diameter (Dg), and arithmetic diameter (Da) of cocoa beans, as also with other similar agricultural products, are important values but not usually easy to determine rapidly by a direct measurement. Nowadays, formula (1), (3), (5), (6), and (7) are used to determine these values for all beans of samples. The results were analysed statistically, and the following general equations can be written to express the relationships between the terms length (L), width (W), thickness (T), volume (V), flat surface area (Af), transversal surface area (At), geometric mean diameter (Dg), and arithmetic diameter (Da) of cocoa beans.

$$V = 0.10L^3 = 0.64W^3 = 2.20T^3 \quad (12)$$

$$A_f = 0.43L^2 = 1.45W^2 = 3.30T^2 \quad (13)$$

$$A_t = 0.15L^2 = 0.52W^2 = 1.19T^2 \quad (14)$$

$$D_g = 0.58L = 1.06W = 1.61T \quad (15)$$

$$d_a = 0.64L = 1.17W = 1.76T \quad (16)$$

The aim of the equations (12) to (16) is that, the volume or the flat or transverse surface area or geometric or arithmetic diameter of a seed can be predicted accuracy by measuring one of the three principal dimensions of length (L), width (W), and thickness (T).

4.2. Experimental result of the of static coefficient friction for cocoa shells

The static coefficients of friction for the hulls against the two different materials were presented in Table 3. The coefficient of static friction of the hulls resting on its outer surface was important on stainless steel than on the carpet. The coefficient of static friction was highest for the carpet when the shells remained on their outer surface.

Table 3: Some Static Angle of Repose (Ө) and Coefficient of Static Friction of Broken Pods Experiment

Material	Fraction shell	Static angle of repose (Ө)	Coefficient of static friction (μ_s)
Stainless	Shell resting on its outer surface	29.25	0.56
	Shell resting on its inner surface	37.60	0.77
Carpet	Shell resting on its outer surface	32.62	0.64
	Shell resting on its inner surface	41.98	0.90

4.3. Experimental results of the destructive loading

The force-deformation curve was analysed to obtain the rigidity of the pod module. The energy absorbed (Ea) by a pod at the moment of rupture is determined from area under the force-deformation curve as expressed below:

$$E_a = \int_0^{D_m} F dx \qquad (17)$$

$$E_a = \frac{F_m D_m}{2} \qquad (18)$$

Where Dm: displacement (deformation) of the pod when the crack starts in compression.
The rigidity modulus is considered as the ratio of the breaking force displacement by compression.

$$S = \frac{F}{D} \qquad (19)$$

Table 4 shows the mean values of tests performed under lateral and longitudinal compression of the cocoa pods and also the weight loss test. The compressive breaking varied from 480N to 820N, 570N to 930N respectively for compression in the lateral and longitudinal axis. After compression, the moisture content of the shells was 81.74% for "Criollo" and "Forastero", 82.74% for "Trinitario". The cocoa pods have a lower breaking strength in the lateral axis relative to the longitudinal axis. Those obtained under the action of the efforts of shock resulting from a steel mass were 1288.70 N, 1600.11 N, and 1120.87 N for "Criollo", "Forastero" and "Trinitario", respectively.

Table 4: Some Breaking Characteristics of Cocoa Pods in Parallel Plate Compression Test and Drop-Weight Experiment

Varieties	Mechanical Parameters					
	Rupture force F_r (N)	Deformation D (mm)	Toughness joule	Stiffness modulus S (N/mm)	Energy absorbed E_a (Nmm)	Falling weight impact F (N)
Horizontal loading						
Criollo	625	11.6	3.62	54.79	2488.24	1288.70
Forastero	720	10.18	3.66	71.58	2505.89	1600.11
Trinitario	600	13.36	4.01	45.17	2411.76	1120.87
Vertical loading						
Criollo	830	12.97	5.42	64.07	4323.96	
Forastero	740	10.39	4.18	72.93	4116.56	
Trinitario	790	14.58	5.81	54.43	4171.10	

4.4. Development of the concept of the design of the cocoa pod breaking machine

Physical and mechanical properties of the pod as well as literature review permits the design of a suitable machine. This designed machine sections the poles and ruptures the pods facilitating extraction of the beans on the hulls.
The cocoa pod processing machine is made up of the parts named on the figure below.

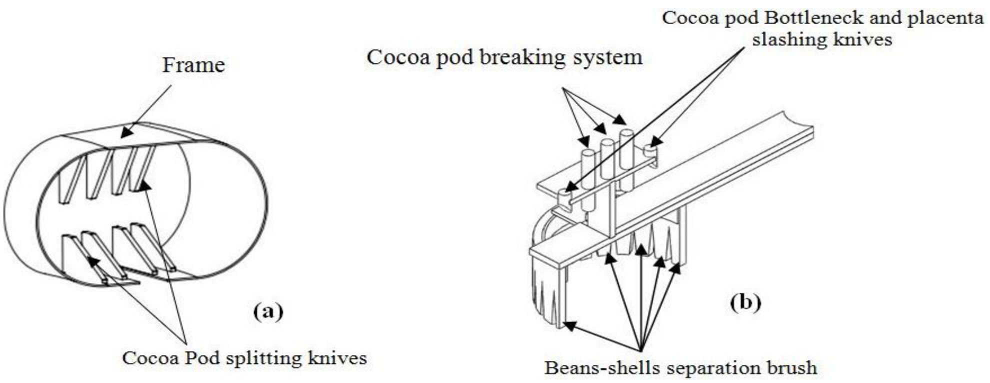

Fig. 5: Design of the Cocoa Pod Splitting Knives: (A) Cocoa Pod Splitting Frame and Knives (with Dimensions), (B) Cocoa Pod Slashing Knives Ready to the End of the Cocoa Pod.

Figure 6 shows sieve size used in Design of pod breaker.

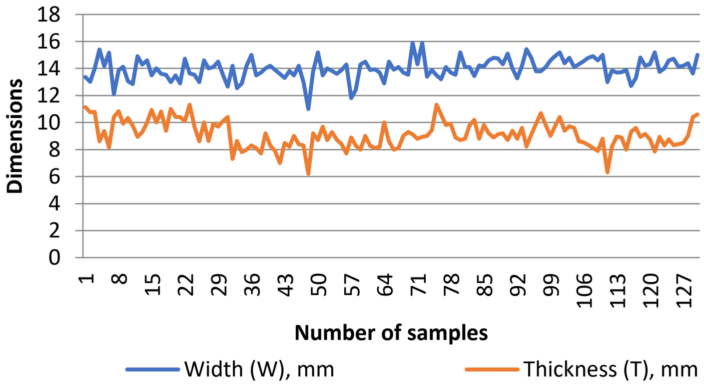

Fig. 6: Dimension Graph for Cocoa Beans.

The separation efficiency should be calculated in terms of percentage of cocoa beans separated as:

$$Separation\ efficiency = \frac{weight\ of\ beans\ separated}{total\ weight\ of\ pod - bean\ mixture} \tag{20}$$

Series of experiments were performed to establish the need for separating the beans and husk after breaking the cocoa pod by selecting an ideal sieve for the three varieties. The identified appropriate sieve sizes for the passage beans and to withhold the shells was 12 mm. The diameter of the sieve, which is the inside diameter of the tank is twice the length cocoa pod breaking arm, was 700 mm, the outside diameter of the shaft carried by the cocoa pod splitting knives arms which is the middle of the sieve was 50 mm.

4.5. Structural resistance of cocoa pod breaking arm

Some computations on a FEM software were carried out to verify the structural resistance of cocoa pod breaking arm.
On the figure below, the scabbing arm present a blue zone showing minimum stress values ranging from 0 to 3.025e+007 N/m².

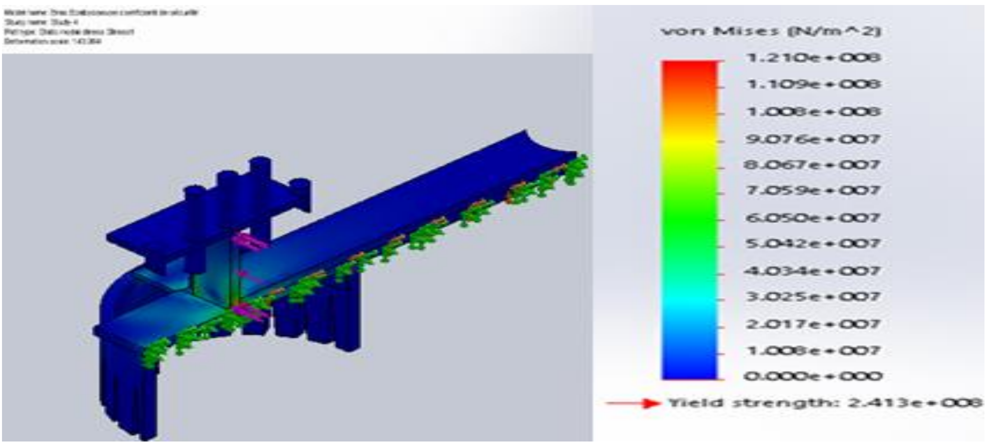

Fig. 7: Representation of the Stress on the Breaking Arm of the Cocoa Pod.

At the green zone the material does not yet show where it can break and this area varies from 4.034e+007 at 9.076e+007 N/m². The red zone shows the values of maximum stress, which represents the critical values, which vary from 1.008e+008 to 1.210e+008 N/m².
The plasticity appears when the Von Mises stress is greater than the limit of elasticity ($\sigma_{VM} \geq \sigma_e$).
Since $\sigma_e = 2.413e + 008\ N/m^2\ and\ \ \sigma_{VM} = 1.210e + 008\ N/m^2$ in this study, the cocoa pod breaking arm will resist to mechanical solicitations.
The figure below shows that the strain does not reach the critical value of the rupture characteristic on the scab arm. The blue area shows elongation values ranging from 0 to 9.281e-005. The green area ranges from 1.237e-004 to 2.784e-004 and shows where the material can break. The red area shows the maximum elongation values that represent critical values ranging from 3.094e-004 to 3.712e-004.
This scabbing arm has a minimal displacement to the maximum displacement which is its critical zone.

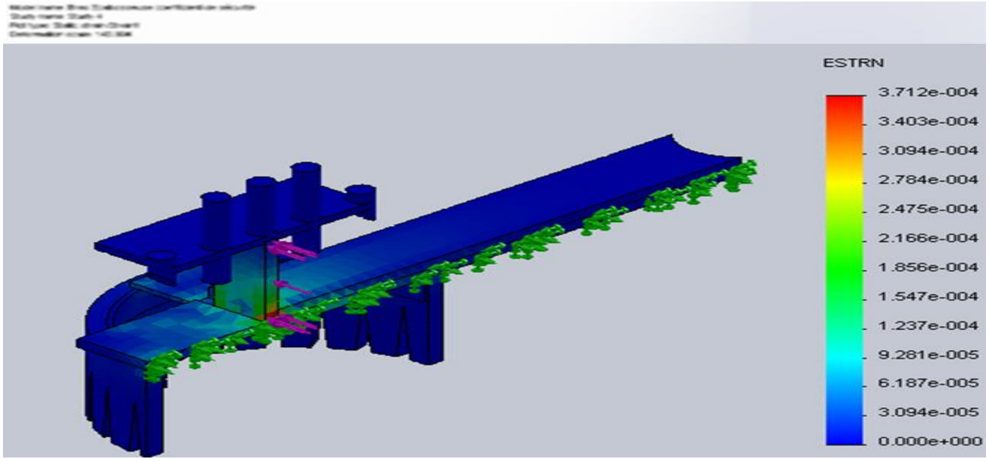

Fig. 8: Strains Distribution on the Breaking Arm of the Cocoa Pod.

Figure 9 presents the displacements distribution on the breaking arm of the cocoa pod. The blue area shows the displacement values ranging from 1e-030 to 4.700e-002mm. The green area ranges from 6.266e-002 to 1.253e-001mm. In this area at the value 1.253e-001 mm the material starts to deform. The red part on this scab is the critical area where the material is completely deformed and this area varies from 1.410e-001 to 1.880e-001mm.

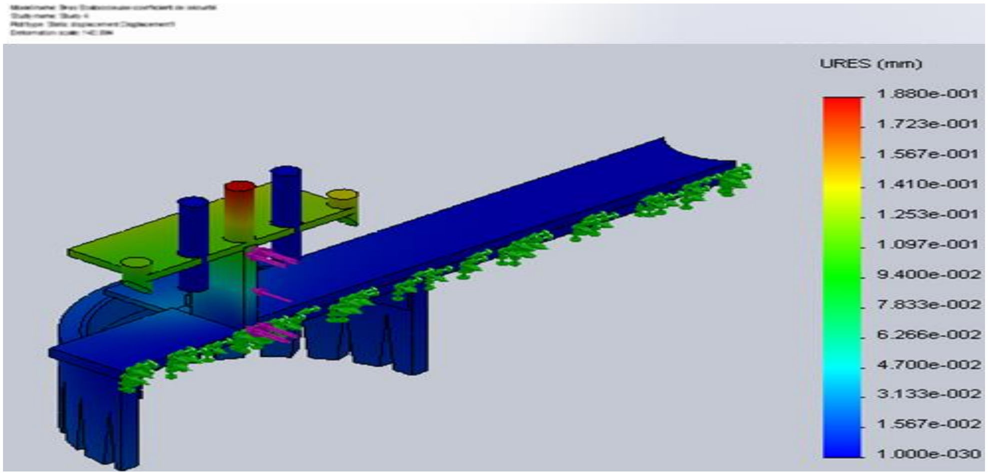

Fig. 9: Displacements Distribution on the Breaking Arm of the Cocoa Pod.

4.6. Design of machine components

The design of a machine to break cocoa pods includes compression and shearing the poles of the pods. The designed machine uses the principle of compression force along the lateral axis of the pod.Certain factors have been taken into account in the design of this machine such as: adequate resistant materials have been used for manufacturing (stainless steel), locally available materials were used in the design of this machine with the ultimate goal of using cheaper materials while meeting all resistance requirements, the machine is developed to have a maximum capacity of 3.5 tons / day (08 hours) so that it can be affordable for farmers. The physical and mechanical properties of the pods and cocoa beans obtained were necessary for the design of this machine. Experiments on the physical properties of pods show that flow characteristics such as sphericity vary between 0.52 - 0.80 and that the angle of repose varied between 30 ° and 35 °. Therefore, the design angle of the hopper is greater than 30 ° to facilitate the slippage of pods. The compression force was used in the design and selection of machine components such as the number of blades in the belly break cage, the knives thickness, the knives length, have been carried out. The gap between the blades and a sieve in a chamber of break of pods influences efficiency of decortication and damage of beans. The sieve sizes were based on the axial dimensions of the beans. According to design calculations, an optimum shaft diameter of 50 mm was calculated to overcome the load on the shaft. The detailed parts of the machine are shown in Fig. 10. Due to human stimulation, the shaft used in the machine was subjected to a variable bending moment and thus to a torque.
Shown in figure 10 is the exploded isometric view of cocoa pod processing machine with the identify parts. The different components of this machine were dimensioned and assembled.

1-Tank, 2-cocoa pod breaking system, 3-Hopper, 4-Main frame, 5-Speed reducer, 6-Guiding wheel, 7-Support wheel, 8-Motor, 9-motor unit Pulley, 10-Reducer pulley, 11-Belt SPA, 12-Chute husk, 13-Chute beans, 14-Coupling, 15-Cover.

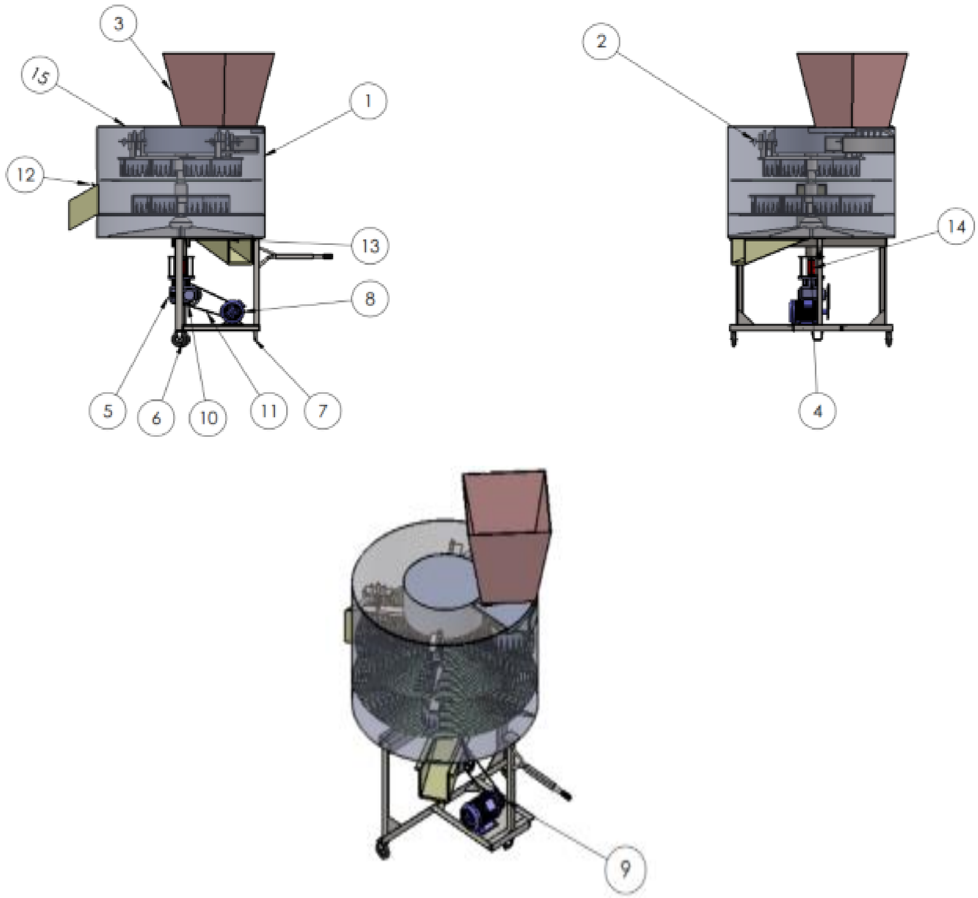

Fig. 10: The Cocoa Pod Breaking and Extraction Machine.

This designed machine severs the poles and ruptures the pods, thus facilitating extraction of the beans on the hulls.

5. Conclusion

This machine model developed during the study is simple and easy to maintain, efficient, cost effective, highly ergonomic and environmentally friendly. This will improve production, quality of Cocoa products to a higher level, exempt from all risks and danger. The time involved in the manual scooping process could be overcome with the help of the machine. The technic of separating beans and cocoa shell debris remained a critical bottleneck in cocoa processing. Numerous infructuous attempts have been made to resolve this problem. The results obtained here show that it is easier to apply the method of mechanical scooping by compression, by cutting the poles of the pod, which will facilitate the detachment of the beans inside the pod. Thus, this will resolve the problem of separating cocoa beans from the husk after pod breaking.

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