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DESIGN OF A CASSAVA PROCESSING UNIT IN STARCH

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ABSTRACT
cameroon produces more than 2.5 million tonnes of cassava a year and nearly half of this production is consumed by local people as a subsistence crop. The activities of semi-industrial or industrial processing of cassava are almost non-existent because of the technological deficit. Hence the need to value local cassava production through the design of reliable and affordable machinery and processing units for farmers or peasant groups. The goal of this work is to design a cassava processing unit for starch. To do this, all our work was conducted at the Department of Mechanical Engineering of ENSAI. We worked on the design of the machines or compartments that were considered more critical for our unit, namely the cassava grater and the separator. The functional analysis approach, through the application of its various tools, made it possible to define the different modules of the machines that were designed. The bibliographic review associated with a field survey and interview allowed the selection of the grating and the separator which served as a basic prototype for the design process of an improved ripper and drum separator.

KEYWORDS : Design, Processing Unit, Cassava, Starch

I. INTRODUCTION

The **Manihot esculenta**, is a multi-year shrubby plant that can grow up to 2 to 3 meters in height and even 3 to 5 meters if not harvested [2]. The stems, 2 to 3 cm in diameter, bear alternate leaves, with multiple leaf lobes, of various forms and of light green to dark green, sometimes purple in the young age (Figure 1). The unisexual flowers, pink, purple, yellowish or greenish are grouped in terminal panicles. The tuberous roots, rich in starch, arranged in bundles, generally reach at the time of harvest 20 to 50 cm long and 5 to 15 cm in diameter (Figure 2). Their weight is between 200 g and 3 kg. In some circumstances they can reach 1 meter long and weigh 20 to 25 kilograms [2]. Note that the plant can grow in all kinds of soil, even very poor and can be harvested after 12 months, especially if the tubers are soft and intended to be eaten raw or cooked in water. Most often, it is done after 18 to 24 months. From a practical point of view, two varieties are distinguished according to their content of manihotoxoside: the **bitter** variety (high content) and the **sweet** variety (low content especially in the skin of the tuber) sometimes consumed raw, after simple peeling, as a treat. More often it is peeled, cut into large pieces and cooked in boiling water. It can then be consumed immediately in the form of boiled cassava.

Figure 1 : Casava Plans

Figure 2 : Cassava tubers

The success of cassava, a native of South America and introduced in Africa by Portuguese sailors in the sixteenth century, is mainly due to its exceptional qualities: ease of cultivation, resistance to parasitic diseases, assured and relatively high yields, possibility of conservation in the soil and availability in any season.

Speaking of world production statistics, cassava is one of the world's leading starchy root crops grown in the world. In 2007 Africa is the world's largest producer with an annual output of 110 million tons, followed by Asia (55 million tons) and Latin America and the Caribbean (37 million tons) [3].

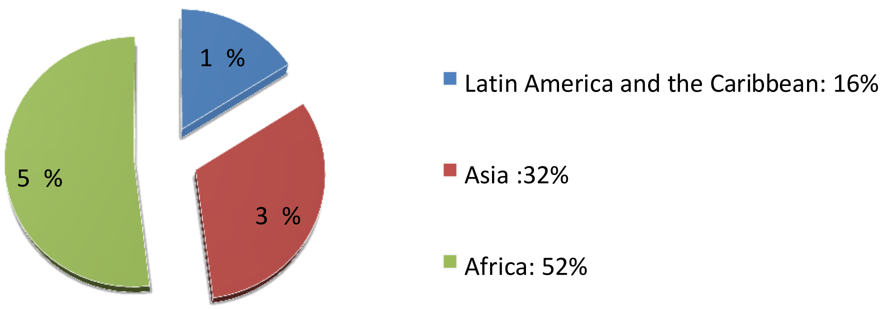

Figure 3: Cassava production worldwide in 2007

According to MINADER in the Yearbook of Agricultural Statistics Campaigns 2007 and 2008, cassava production in Cameroon is estimated at 2,882,734 tons. The PNDRT in 2005 estimated that of the 2,349,171 tons of cassava produced in Cameroon, consumption of fresh or processed cassava amounted to 1,136,000 tons. There are three scales of cassava processing: **industrial processing**: which employs large processing units. It consists generally in the production of starch; **semi-industrial processing**: used by medium processing units. It is used to make starch, tapioca and sometimes cassava flour and **artisanal processing**: using rudimentary equipment such as mortars, pestles and so on. It is generally intended for the production of food such as the cassava stick attieké (Côte d'Ivoire). It is also used for the manufacture of starch but in a small proportion. Of all the speculations of roots and tubers produced in Cameroon, cassava is the most transformed speculation [4]. Cassava starch is the best-known cassava by-product on the world market [2]. It is used in a wide range of applications: stabilizers in soups and frozen foods, tablet coating, paper coating, stamp and plywood adhesives, textile finishing, raw material for the manufacture of ethanol and binder for concrete. As a source of starch, cassava is highly competitive: the root contains more starch, in dry weight, than almost all other food crops, and is easy to extract using simple technologies [1]. There are two methods of extraction: by **dry way**: by sieving flour obtained by hammer milling of sun-dried and by **wet way**: by sieving the cassava pulp, obtained after peeling the roots and grating under a net running water. This is the most used technique because it allows to obtain starches of higher purity. Extraction techniques depend on technological means. In the rustic workshops, the cassava wet cassava starch extraction steps are as shown in Figure 4. The literature gives more details on the processes of wet starch extraction in rustic workshops [3].

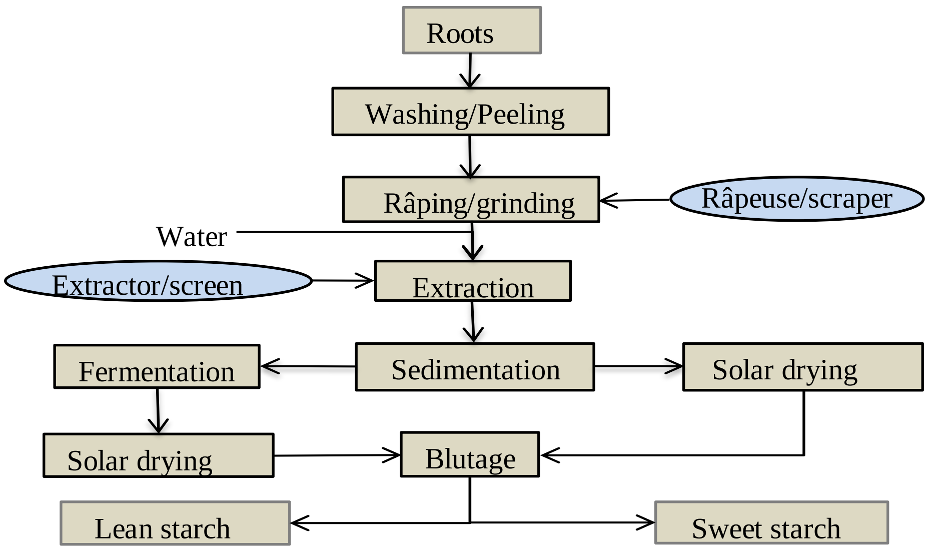

Figure 4: Process of wet starch extraction in rustic workshops

Cassava starch extraction equipment is diverse. They differ according to the scale of transformation and sometimes according to the financial means of the starch producers. Each extraction step is done either manually or mechanically, in some cases both. But note that the important steps in the process of starch extraction are grating and separation the rest can be done in the sedimentation tanks and manually. Thus, there are several ranges of raspers and separators on the market [3], [5], [6], [7], [8], [9], [10]. We carry out the synthesis of the equipment of the bibliography taking into account the socio-economic and technological parameters. Thus, we have on one hand the **synthesis of rapeuses** and on the other hand the **synthesis of separators**. Referring to the **synthesis of rapeuses**, bibliographic analyzes show that raspberries are the most used for a scale of semi-industrial production. Based on the notions of safety, physical contribution, risk of accident, aesthetics and grating rate we make a comparison between the various equipment mentioned. Note that each of the equipment does not have the same advantages and disadvantages. Table 1 below summarizes the different advantages and disadvantages of rapeuses / grinders in the context of our work.

Tableau 1: Synthesis of the types of cassava rapeuses

Type rapeuses	Manufacturers /owner	Advantages	Disadvantages
Manual grater	dealer of iron	simplicity of design and manufacture	-requires heavy physical effort -very slow -risks of injury - subject to rust
Classic grater	GIC LEMA.	Mechanized grating	-Risk of accident -risk to damage the rasp. -Subject to rust.
	CIAO Group	Mechanized grating	-can not speed up the grating rate. -sujette also to rust. -the cassava pulp is harvested almost on the ground.
Piston rapeuse	DEKLERCK BEXEN.	−Mechanized grating. -reduces the risk of accidents. -increases the grating rate. - easy work.	Need an operator to manipulate the piston.

Table 1 above shows that only conventional and piston scrapers are well suited to small and medium-sized businesses. However, the fact that piston scrapers increase the rate of grating, reduce the risk of accidents and are easy to maneuver lead us to think that they are better suited than conventional rasps. Speaking of the **synthesis of the separators**, we make here a comparison between the different separators. The major points on which we rely are much more based on the simplicity of the design ease of maneuver and aesthetics. Table 2 summarizes the advantages over each other of the separators mentioned in the literature review. However, it appears that drum separators are better adapted to semi-industrial scale processing because the process is immune to external contamination and is of design simplicity.

Tableau 2 : Synthesis of starch separators

Types of separator	Advantages	Desadvantages	Type of operation
Vibrating sieve separator	- Mechanized process ; - simple design.	-request a lot of water, -requires the action of an external operator to spread the cassava pulp, -the separation chamber is in the open air.	Discontinuous
Puller halfway.	-Mechanized process ; - simple design.	-The brewing chamber is in the open air; -Cleaning difficult.	Continuous.
Sieve drum with internal blades.	-Mechanized process. - simple design - brewing chamber protected from external contaminations.	-low rotational speed.	Discontinuous
Rotary drum with worm.	-Mechanized process; - brewing chamber protected from external contaminations.	-The design is a more complex; asks for more financial means; - low speed of rotation.	Discontinuous
Extractor batch.	Mechanized process	- complex design, -subject to vibrations, -risk of contact between the bottom and the propeller.	Discontinuous
Centrifugal separator.	-Mechanized process; -protection protected from contamination; - good ratio of energy consumption to production.	- complex design, -reserved for modern starch.	Continuous.
Râpe extracteur.	-Encombrement réduit, -processus mécanisé.	- complex design, -inability to perform one of its functions would automatically paralyze the equipment.	Discontinuous

II. MATERIALS AND METHOD

The Manihot Esculenta (cassava) is our study material as it is titled in the theme of this paper. The tool solicited for computer-aided design is Solidworks version 2010. Speaking of the methods used, after carrying out a bibliographic analysis our work process consisted in carrying out technical analyzes of some prototypes of already existing equipment. To do this, we have conducted field visits to obtain interviews with certain individuals who have cassava processing equipment and even some brewery units to gather certain technical and practical arguments allowing us to conduct a good analysis critical of the machines observed (problem of dimensioning, lack of maintenance and difficulty in the maneuver). From this descent

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and from the bibliographic and technical review of some machines, we were able to retain the prototypes that inspired us to design our machines. The design process refers to the stages of development of the solution to the problem. We adopted the design method by functional analysis since it expresses, not only the needs in the form of function, but also presents the point of view of the user, allows the analysis of the constitution, the organization and internal functions of the short product best suited. It allows, through its various tools (horned beast, octopus diagram ...), to better identify the problem to be solved, to determine the functions to be fulfilled, as well as the appropriate technological solutions. The phases of the functional analysis are: **functional analysis of the needs**: which expresses needs in the form of functions in terms of services rendered or expected. A function is an action of a product expressed in terms of finality. This analysis therefore presents the point of view of the user.The Functional Specifications (CdCF) presents this need modeling in the form of a set of validated, characterized and hierarchical functions. The CdCF is a document that evolves and grows progressively during the creation of the product, from the "need capture" to the launch of "development" [11]. We also have **technical functional analysis**: who can to be subdivided into several phases among which we will be much more interested in the SADT (Structured Analysis and Modeling of Systems) method, which uses successive refinements to produce specifications whose essence is in the form of graphical notation in diagrams data streams. The highest level represents the whole problem (in the form of activity, data or process, depending on the method). Each level is then decomposed respecting the inputs / outputs of the higher level. The decomposition continuous until reaching "controllable" components.

III. RESULTS

The descent on piece of ground

We made descents in the cities of Limbe, Douala and Ekona. There we met a few individuals with cassava rippers and some scrap metal manufacturers of agro-industrial equipment. During interviews, it emerged that the major problems facing these facilities are mainly related to the lack of adequate dimensioning of the elements and the type of material used for their manufacture (unsuitable for the food industry). Some of these scrap dealers do not have the means to obtain good quality materials. However, we were able to note that the rapeuses met were of classic type from where the difficulty of maneuver and the exposure to the risks of accident. These rapeuses presented above, are worth 779.40 USD plus state subsidies. Although these individuals have equipment such as cassava raspers, we were told that their know-how was not limited to use: no maintenance was applied. From this investigation conducted and the synthesis made in bibliographic analysis we have retained mechanized piston graters as our working prototype. As for the separator, the prototype chosen is essentially based on the analyzes made in the literature. The prototype selected for our work is the drum for to sift type.

Results of functional analysis

- **Research of the fundamental need**
- **Application of the horned beast**

he tool "horned beast" asks the following questions for the products to study:

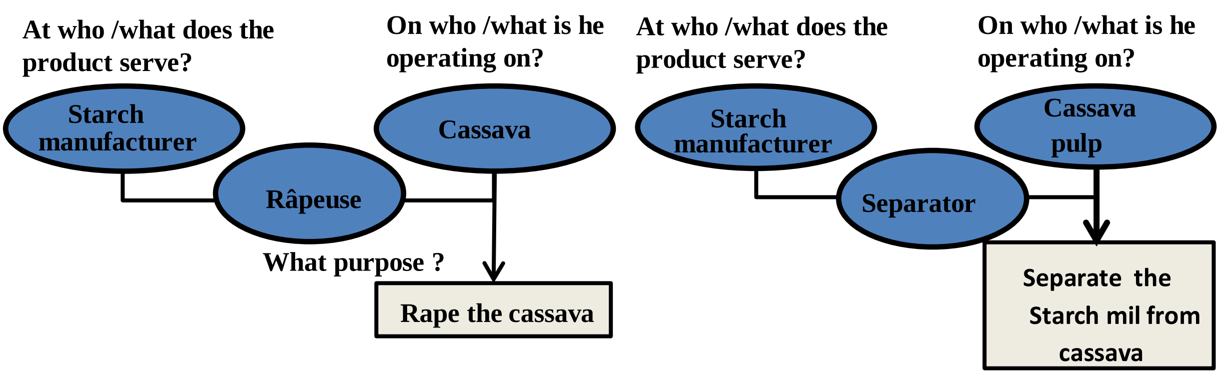


Figure 5: The Horned Beast of the rapeuse (left) and separator (right)

The object of the design can then be stated as follows: the grating allows the starch manufacturer to crush the cassava by grating and, the separator allows the starch manufacturer through the separation to obtain the milk of the starch. starch, cassava pulp.

- **Octopus diagram**

for define the functions of our system, we use the representation tool called "octopus diagram". Knowing the previously stated need of the horned beast tool, and taking into account the specifications of the design objective, we build the APTE diagrams (or octopus diagram) of the grating and separator in Figures 6 and 7 below:

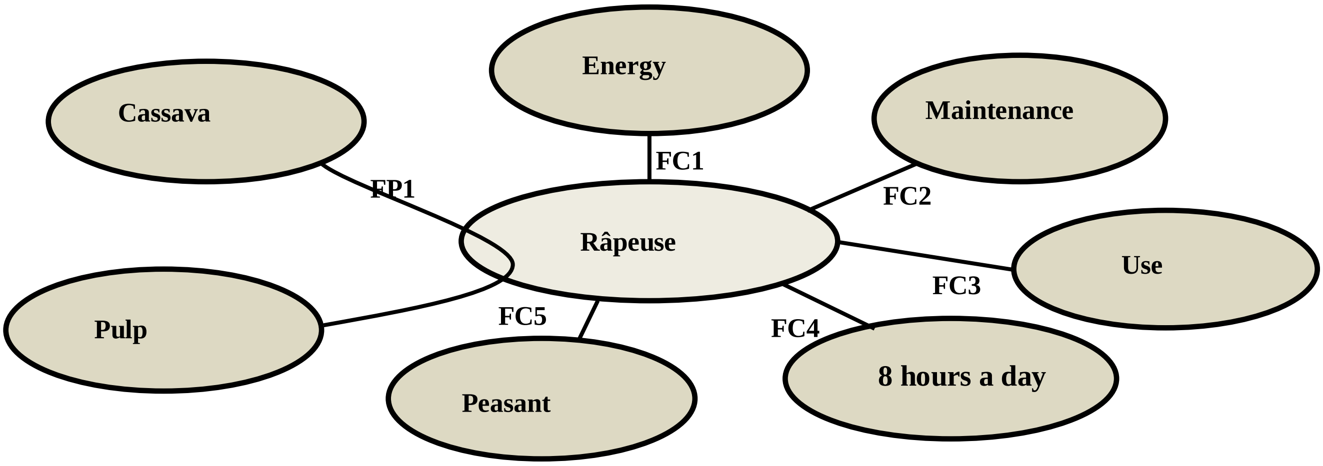


Figure 6: Octopus diagram of the rapeuse

The following table summarizes the statement of service functions.

Tableau 3: Statement of Service Functions of the rapeuse

Functions	**States needs**
FP1	Reduce pulp cassava ;
FC1	Allow training by electric motor or gasoline or diesel;
FC2	Easy maintenance for the user;
FC3	Allow easy handling for the user;
FC4	Operate at most 8 hours per day;
FC5	Make for small communities.

Similarly for the separator, we develop its octopus diagram.

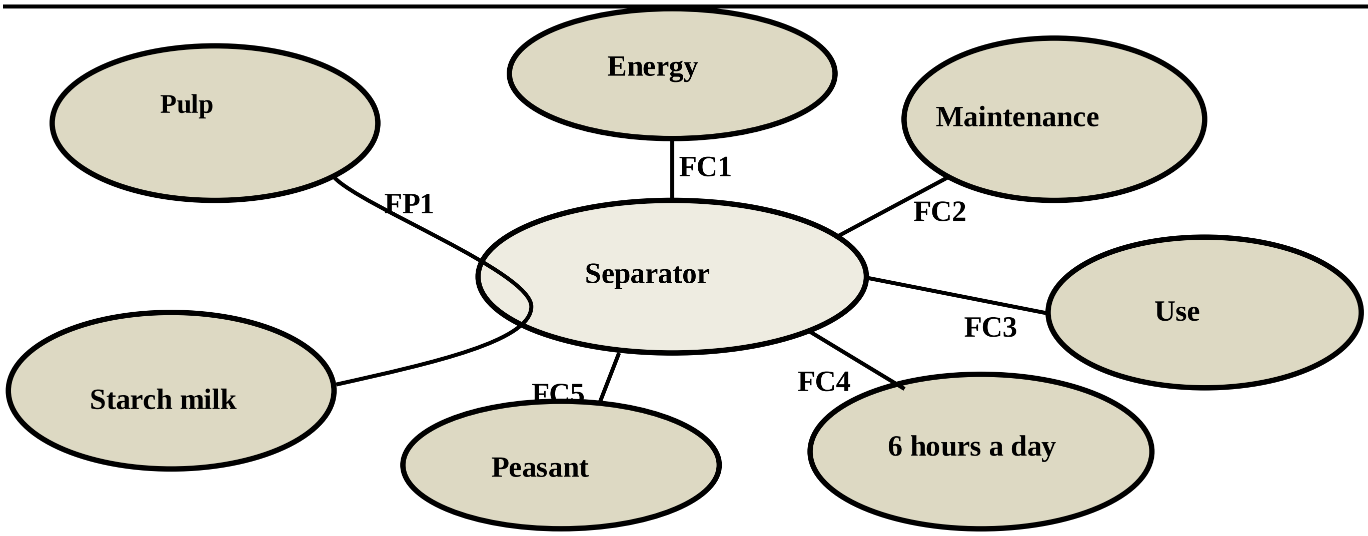


Figure 7: Octopus diagram of the separator

The following table gives the statement of the service functions for the separator.

Tableau 4: State the technical functions of the separator.

Functions	**Enoncé des fonctions**
FP1	Separate the starch milk from the cassava pulp;
FC1	Gear trainer ;
FC2	Easy maintenance for the user;
FC3	Allow easy handling for the user;
FC4	Operate at most 6 hours per day;
FC5	Make for small communities.

- **Research of technological solutions by the SADT method**

The diagram allowing the best representation of the present project is the actigram which takes as input the Manihot esculenta, and as output data the milk of starch. The activity on which one acts is the transformation of cassava, figure 8 gives the actigram of first level.

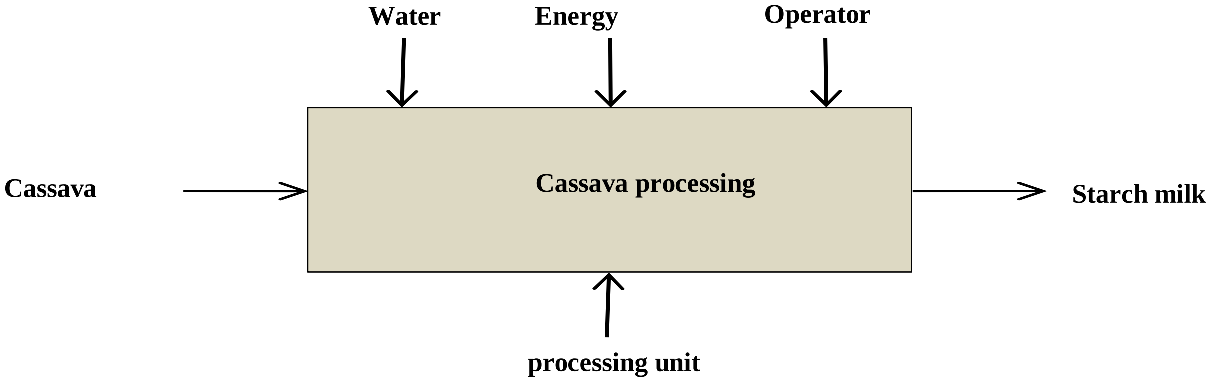


Figure 8: Actigram of the processing unit (Level 1)

The need to present the system accurately leads us to the Level 2 Actigram (Figure 9), and the Level 3 Actigram (Figure 10).

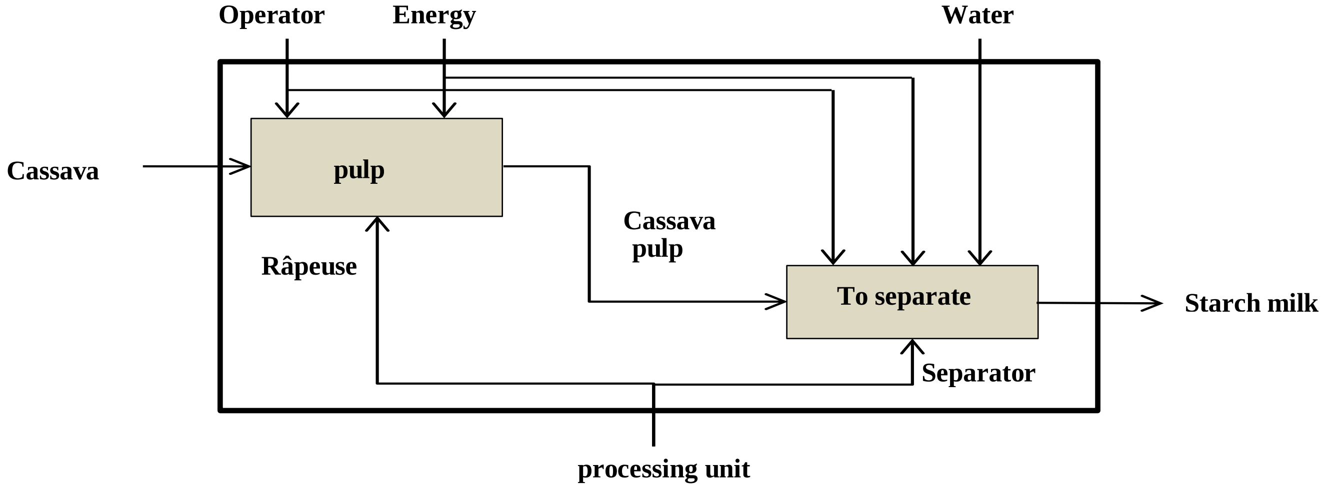


Figure 9: Actigram of the processing unit (Level 2)

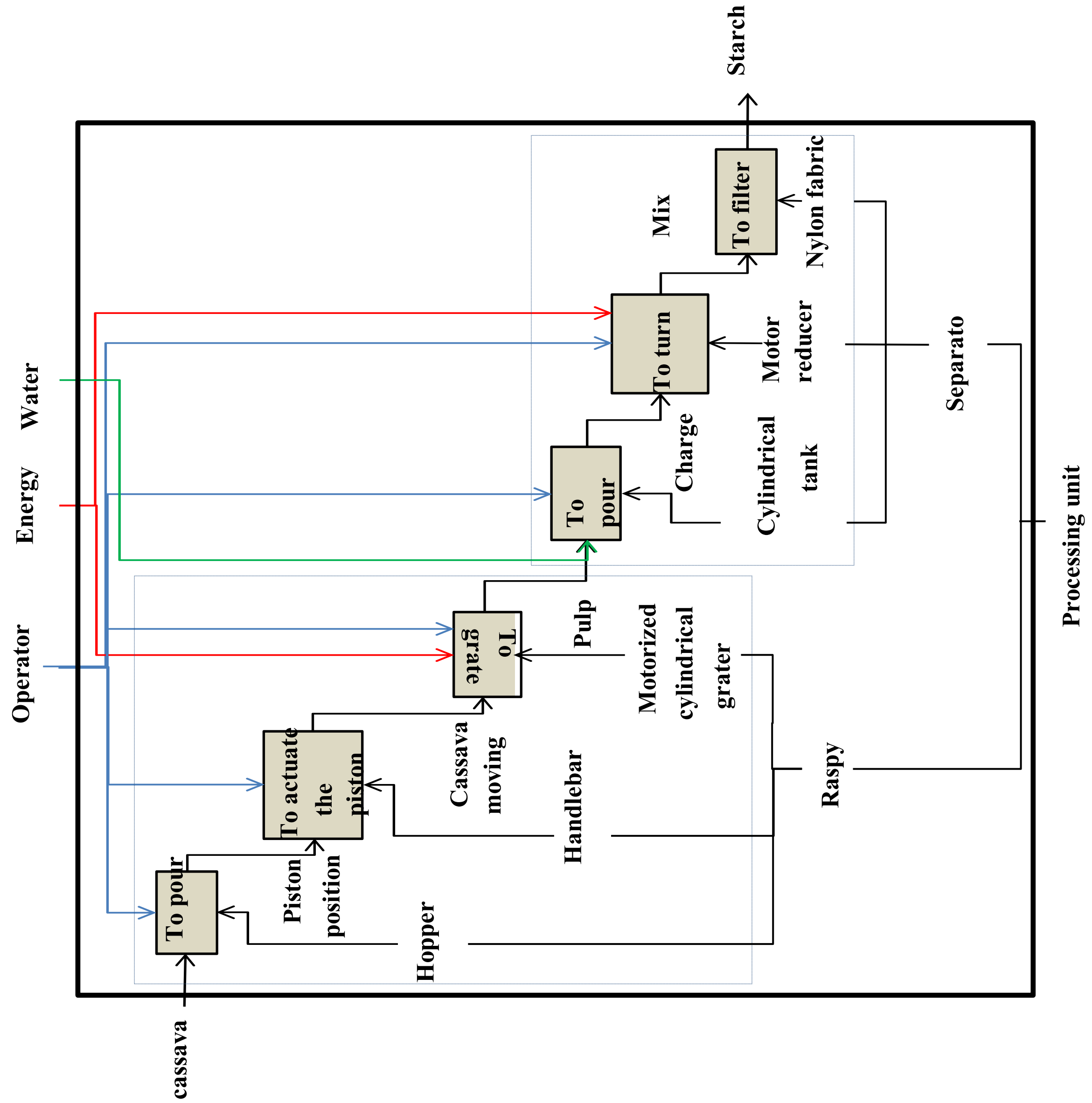


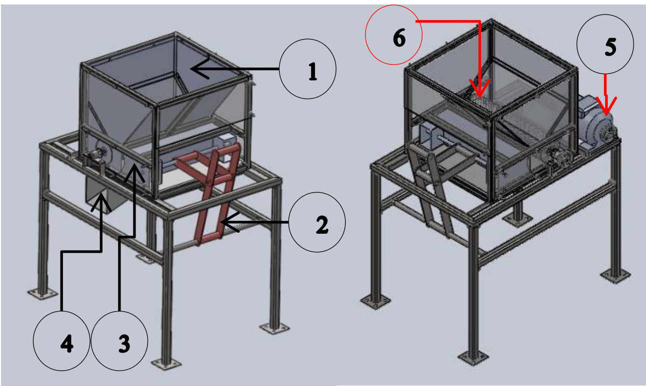
Figure 10 : Level 3 actigram

Proposals for solutions

- **The râpeuse**

Sketch

Figure 11 below shows the scheme of the proposed rapeuses.



Legend **:**

1 : hopper.

2 : handlebar.

3 : piston/drawer.

4 :Exit.

5 :Driving motor

6 :grate

Figure 11: 3D view of the proposed rapeuse

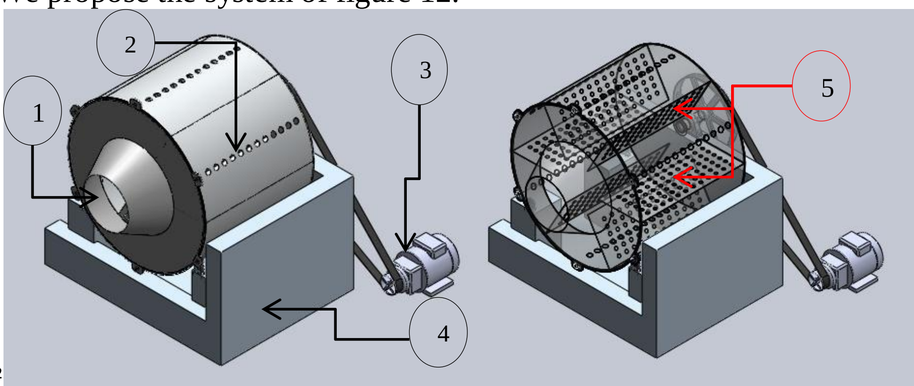
Operating principle

The motor (5) is started. The cassava is then poured into the hopper (1). Using the handlebars (2) we make the drawer (3) move back and forth. When the handlebar is pulled back, the cassava enters the grating area. The handlebar is then pushed forward. The cassava begins to be grated and the pulp is collected at the outlet (4). When the handlebar reaches the end of the race forward, we just have to remove it to restart the operation.

- **The separator**

Sketch

We propose the system of figure 12.



2

Legend

1 : Input of cassava pulp

2 :tumbler orfices

3 : motoreducteur

4 : foundation.

5 :Internal blades.

Figure 12: 3D view of the separator

Operating principle

The principle of operation remains the same as that of the drum to sift, the only difference being that here we have 6 blades (5) perforated with small holes to accentuate the water-mashed cassava mixture. The drum (2) is rotated. The cassava is poured through the opening (1) and the system is supplied with water. The blades then accentuate the mixture and the starch milk is discharged through the orifices which are on the lateral surface of the drum. The outgoing starch milk is collected in the foundation (4) on the floor, before being directly drained to the sedimentation tanks. The holes on the periphery of the drum are first covered inside with a cloth to let only the milk of starch.

IV. CONCLUSIONS

At the end of the work done, we designed the two machines or compartments which seemed to be quite decisive in the cassava starch production unit on the semi-industrial scale namely, the grating machine and the separator. The design process consisted first of all to carry out field investigations and to carry out bibliographical research in order to fix ourselves prototype machines while respecting our socio-economic stakes. The work carried out resulted in the definition plans for each machine. With an average value of 2 906.38 USD, coupled with good productivity, our equipment unquestionably brings opportunities contributing to new initiatives in "the valorization of cassava in Cameroon and even in black Africa", still little known until now by local populations. However, even if we put at our disposal equipment intended for the production of cassava starch, the concern to be eradicated will be nothing other than the ambient poverty, through the improvement of the level and conditions of production in rural environment.

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