Design of a Prototype of an Olive Oil Extraction Machine for Home Use

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Absrtact: The mechanical methods used to extract virgin oils from olives are of two types: the discontinuous system and the continuous system. In any case, the system defined as "continuous" is composed of several steps, not all of which are completely continuous, due to the presence of the batching device. The aim of this work was to design a prototype of a home olive oil extraction machine with a heating device to be placed immediately before the filtration step to facilitate solid / liquid separation. This strategy represents the first step towards the transformation of the step of mixing a discontinuous operation into a continuous real process. The design, analysis and simulation were done using Catia and Abaqus.

Keywords: Oil extraction, trituration, kneading, 3D printing, olive, harvesting, olive oil....

1. Introduction

The olive tree constitutes the main fruit speculation cultivated in Morocco, with an area of 920000 ha. This sector represents more than 57% of the national arboreal sole, extending over the entire national territory, with the exception of the Atlantic coastal strip, because of its adaptability to all bioclimatic stages. Production has nearly doubled in six years to 1.5 million tones, and Morocco has become the world's fifth largest producer and exporter of olive oil. In terms of new plantations, outputs are ahead of the forecast of the program contract, covering an area of 224,500 ha between 2009 and 2016, ie an average annual growth rate of 37,420 ha ... It is intended Up to 75% on trituration. The remainder (25%) is divided between canning and self-consumption.

The olive oil sector is made up of modern, semi-modern units and traditional 'Maâsra' mills. The average production of olive oil in Morocco in 2016 is 138,300 T / year, an increase of 87% compared to the 2004- 2008 period (74,000 T / year).

According to the IOC (International Olive Oil Council), olive oil is an oil obtained from the fruit of the olive tree, excluding oils obtained by extraction with solvents, by re-esterification procedures, or By any mixture with other types of oils [1]. Unlike other vegetable oils or other products such as wine, olive oil does not require any refining or chemical transformation. Thanks to this procedural simplicity, olive oil has been manufactured since antiquity [2]. The

technique has undergone many changes over time [3], which can be grouped into two main categories: changes relating to olive crushing and changes related to the separation of the different phases. Between these two great steps, the olive paste is kneaded in order to be homogenized and to allow the coalescence of the oil droplets.

When they arrive at a mill, the olives are weighed and then generally passed through a washer-scrubber system which will clean them and allow them to remove impurities (soil, pebbles, leaves, etc.) before grinding. The purpose of crushing olives is to destroy the olive cells so that they can release their contents. At this stage of the process the olives are reduced to a more or less homogeneous paste which must be kneaded. In addition to the role of homogenization of the dough, the mixing tank allows the coalescence of the oil drops [4] [5] [6]: the oil droplets which have just been released from their cell lipo- vacuoles will group together to form more drops Large size that will be easier to extract from the dough[7] [8]. The kneaded paste will then be pressed or centrifuged horizontally to separate the solid and liquid phases.

The solid phase contains the remains of the nuclei as well as the skin and pulp of the olives devoid of its oil. This solid phase is called "pomace" and is one of the two main co-products of olive oil production.

The liquid phase is a mixture of water and oil that must be separated. This is done either by simple gravitational decanting or by centrifugation. In both cases, the aqueous phase, also called "margins", is separated from the oil and is the second co-product of the manufacture of olive oil.

The fatty phase is pure olive oil; As no further treatment or chemical reaction is required, olive oil is edible as it is.

2 Process and operations

2.1 The harvest of olives

There are many methods of harvesting olives that vary according to the final destination of these olives, the nature of the soil and the size of the farm. The traditional method is hand harvesting (FIG. 1A), it is the most respectful of the tree but the harvest is tedious and very long.

The most commonly used method is (FIG. 1B): olive growers place a net on the ground and use a comb that will tear off the olives from the branch and make them fall on the net.

There are now mechanical combs (FIG. 1C) equipped with a motor rotating the combs at the end of a telescopic handle. This technique allows a faster harvest of olives and remains a little traumatic for olive trees.

The technique used most on large farms is that by vibration of the branches (FIG. 1D): metal clamps clamp the trunk of the olive tree and a high frequency vibration will be applied to the trunk. The ripe olives will then fall from the tree and can be used for oil production. The main disadvantage of this system, besides its purchase cost, is the damage it can cause to the young branches of the olives.

A B C D

FIG. 1: Harvesting olives by hand (A); with the hand comb (B); to the mechanical comb (C); by vibratory machine (D)

2.2 The trituration of olive

The very first olive trituration systems were used by the Hebrews (10th century BC), which pounded olives in large mortars. The paste obtained was then extremely coarse and very little oil could be removed therefrom. This technique, which is not very practical because it is difficult to apply on a large scale and above all not very efficient, has gradually been replaced by grinding mills. The first mills with granite wheels were in the category of blood grinders (Figure 2). The most commonly used animals were horses and cows. The mills were then gradually replaced by water mills, which increased the number of grinding wheels in action and thus reduced crushing times.

During the 20th century, the mills were modernized and electrified. Granite wheels are now powered by electric motors, which facilitates the work and allows to work with 2 to 5 identical granite wheels (FIG.3) or different sizes.

Although the electrification of olive trituration systems has increased the efficiency of the system and reduced the work of the mills, this process remains relatively long in view of the increase in demand for oil, Increase in mill size. For this purpose, different metal grinder systems have been developed (FIG. 4)

FIG. 2: Granite wheel driven by a cow

FIG. 3: Granite wheel with two wheels

FIG. 4: Shredder

Metallic systems accelerate the grinding process, thus increasing daily production volumes and are particularly suitable for continuous production systems.

2.3 Mixing

Whatever the technique of trituration, a step is essential before the separation of the different phases of the dough, it is the mixing. The purpose of kneading is to homogenize the olive paste, but it will also and above all allow the coalescence of the oil droplets [9].

Mixing is done by slow rotation of a worm which will continuously return the dough (FIG. 5)

FIG. 5 : Worm mixer

2.4 Solid / liquid separation

Two solid / liquid phase separation systems are used: a press system and a horizontal centrifugal system The press (FIG. 6) has been used since the beginning of olive oil production. Originally, the olive paste was placed in double discs of braided coconut fiber, connected by the outer edge and pierced in the center, called "Scourtins".

The miller loaded the dough into the latter, then stacked the discs before pressing them with the force of the arms.

Technological progress has led to the development of automated and less tedious systems than the presses: these are the horizontal three-phase centrifuges (FIG. 7), they separate:

- Pulp (solid waste)
- Oil with a little water
- Margins with a little oil

Technological advances and a better understanding of the phenomena occurring within the centrifuge have made it possible to develop horizontal two-phase centrifuges (FIG. 8). The main advantage of this type of system is that no additional step is required after centrifugation: when the apparatus is properly adjusted, the olive oil will be separated directly from the wet cakes.

FIG. 6 : Press System

FIG. 7 : Horizontal three-phase centrifuge

FIG. 8: Horizontal two-phase centrifuge

2.5 Oil / water separation

Olive oil and water have very different densities (0.913 for olive oil, 0.9982 for water at 20 °C), so that these two liquids can not be separated by gravity Under standard conditions. The simplest method for separating them is therefore gravitational decantation. For this purpose the liquid phases are placed in stainless steel tanks (FIG. 9A)

In order to accelerate phase separation, the oil / water mixture is passed through a centrifuge (FIG. 9B). The speed of rotation of the centrifuge will break the emulsion and favor the separation of the two liquid phases.

Fig 9. Oil / water seperation systems

3 The machine in question

3.1 Need

The machine allows us to produce olive oil at ho; it is a transformation of a set of industrial machines into a single machine, keeping the same stages of production of oil.

3.2 SysML Analysis

The SysML language - Systems Modeling Language - is a modeling language specific to the field of system engineering. It allows the specification, analysis, design, verification and validation of many systems.

The SysML analysis of our machine is structured around three types of basic diagrams:

- A requirements diagram (FIG. 10) that specifies the capacity and constraints that must be met by the machine.
- A use case diagram (FIG. 11) that identifies all the functionality that the machine must provide.
- A block diagram (FIG. 12), which gives an idea of the internal structure of the machine. It describes the system hierarchy and the system / component classifications.

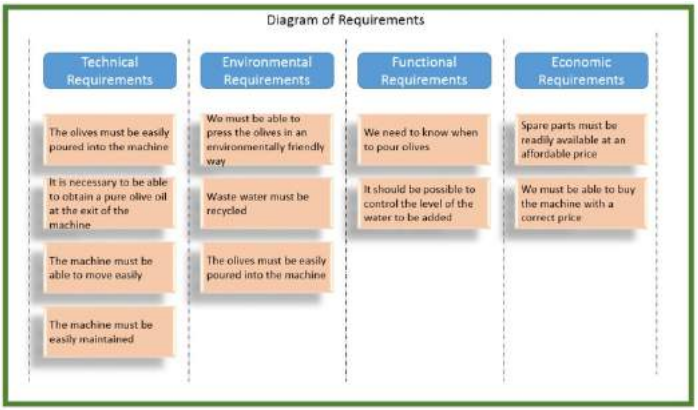


FIG. 10 : Diagram of Requirements

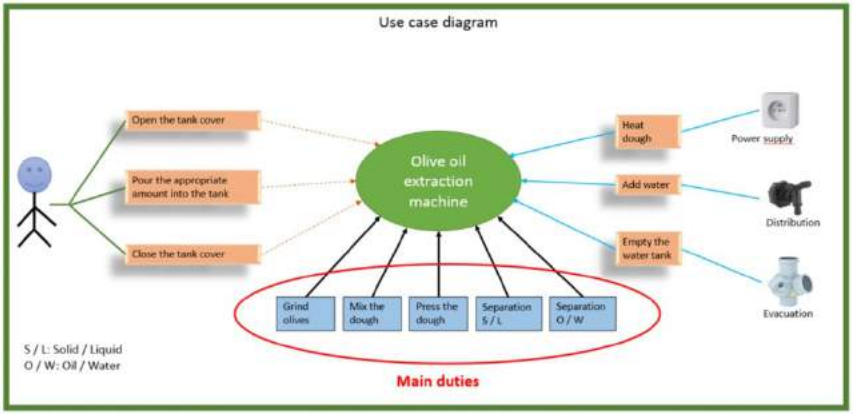


Fig 11. Use case diagram

4 Design study

4.1 Description of the machine

The olive oil extraction machine presented in this work is a combination of the set of steps mentioned above.

It consists of an olive crusher (core and pulp), and a press with which all the oil is removed from the dough by a single operation

How is the grinding done?

The olives are conveyed from the vat to the gear shredder. The grinder gears are driven by an electric motor, and to avoid overloading, a sensor for detecting any kind of overload is installed. The sprockets are made of stainless steel.

How is pressure created?

The crushed pulp is fed to the pressure stop by the propeller. As the pressure stop partially obstructs the outlet, the pressure rises in the chamber constituted by the inner ring of the filter and the filter. The pressure rise is also partially created by the stopper which is at the outlet and which completes the action of the stop.

Since the pressure in the inner ring of the filter is high, the olive paste is pressed and the oil thus extracted escapes via the easiest path, i.e. the gap of the inner ring of the filter . This gap, on the other hand, is too narrow for the grunions which are evacuated via the outlet plug to pass through.

To facilitate the operation of the solid / liquid separation, a heater is installed on the propeller liner and before the inner ring of the filter, but the olive paste must not exceed a temperature of 27 ° C.

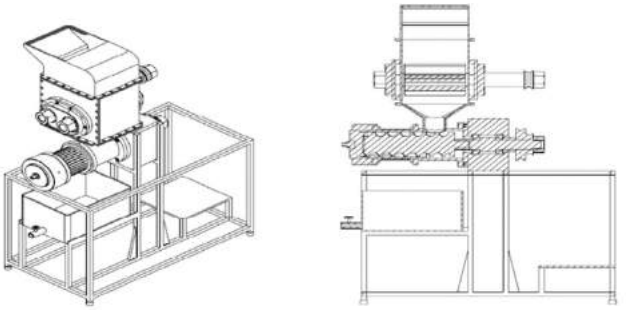


FIG. 13 : Design of the Olive oil extraction machine

4.2 Identification of individual parts (3D printing)

Prototyping new products or improving existing products is the most developed commercial application at present, covering almost 70% of total market transactions in three-dimensional printing.

3D prototyping provides designers, engineers and even consumers with an ideal way to produce functional objects first.

The reason why we made the first prototype of our machine on a 3D printer (FIG. 14). FIG. 15 shows all the basic parts of the machine

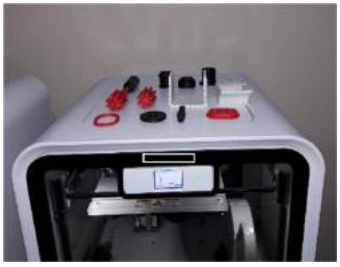


FIG. 14: The 3D printer used in prototype manufacturing

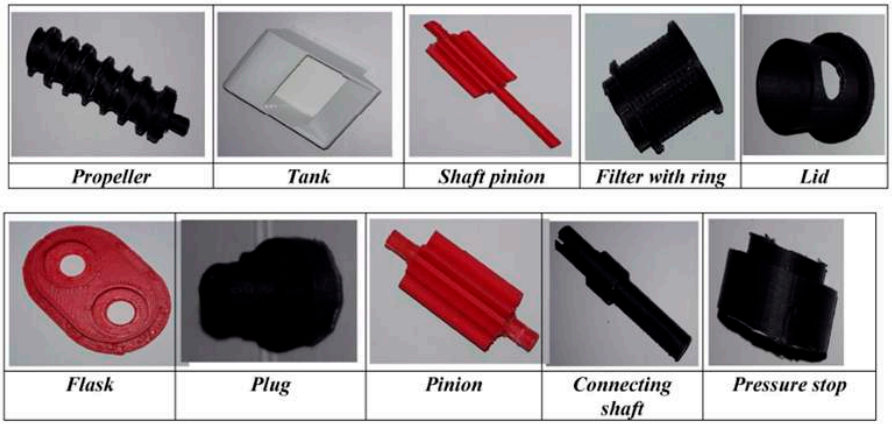
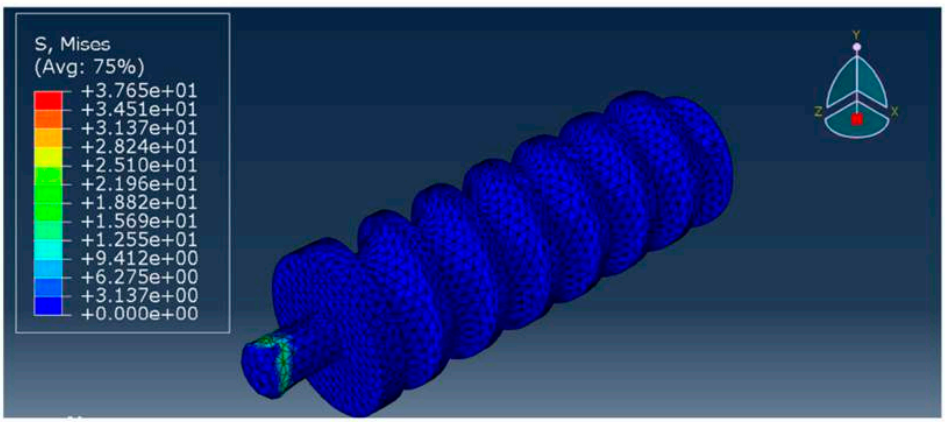


FIG. 15: *The various basic parts of the olive oil extraction machine*

5. Simulation study in progress

The work of the simulation is in progress and aims to optimize the main piece (the propeller). A first try as presented below, show that the piece isn can be optimized.



6. Conclusion and Perspective

The most important challenges of this article are:

- Design an olive oil extraction machine that uses ultrasound in its oil production process due to the advantages of mechanical and thermal effects and increased extraction capacity and reduced treatment.
- Set up a system to recycle sewage from separation
- Integrate a waste treatment system.

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