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GEOMETRICAL DEFINITION AND VIRTUAL RECONSTRUCTION OF THE VERTICAL CAGE AND HORIZONTAL PLATE PRESSES FOR GRAPE MUST EXTRACTION

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Abstract

The wine industry is changing very fast in Spain. Although the number of consumers is declining now, we are facing an automated market where new brands continue to emerge. Internalization or concentration of producers, are some of the keys to the future that will ensure the survival of this industry in our country and it should be increasingly competitive.

The present research work studies the evolution of the wine extraction presses and specifically the vertical screw press and the horizontal two plates press by manual and mechanical operation respectively. This last one arises from the development of the first press model with horizontally round cage produced by Mr. Vaslin.

On the other hand, this work seeks to highlight this part of our history that is the wine culture, thanks to virtual reconstruction of a vertical press and the horizontal press. As a result, it is expected to obtain the operation of working of these presses in order that they do not stay in the oblivion, since they form a part of our industrial heritage, dedicated to gathering the remains of the industrial culture.

So the aim of this research is to promote the importance of this heritage as source of identity, holder of universal cultural values, and as a potential tool of technological and scientific development. For this, we have used reconstruction techniques based on CAE technology. Thus there is achieved that those machines that have been part of the wine history do not stay in the oblivion, enriching culture and current technology as they had been precursor of the functioning from current technologies for the industrial transformation of the grapes.

1 Introduction

The first graphical or written references of the wine-growing presses date back from the Ancient Egypt and to the Classic Greece. The vineyards were in the Delta and in the oases, being present both the press in Egyptian hieroglyphs as the offerings of wines in the pharaohs tombs from the first dynasty onwards.

The Romans extended the culture of the grapevine and the production of the wine beyond the *mare nostrum*, including the Roman provinces of the Iberian Peninsula.

The Greeks settled the origin of the wine in some place of the Mediterranean and they were granting the merit of the invention to Dionisos, adopted child as Baco for the Roman mythology.

The operations used by the Romans to obtain wine from the transformation techniques of the grapes, laying the foundations of the future Spanish wine industry. For this reason, it is suitable to do a brief review of the process and the machinery used, as a base to analyze its evolution to the present day: the squeezed bunches in a place named Torcularium [1] and immediately afterwards the marc was getting in a Torcular press, getting the juice.

The pulleys and ropes of the *Torculo* were rapidly replaced and the evolution drove to the employment of levers in order to increase the force for unit of surface or pressure.

To this system belong the press of lever, lever and wheel and beam and screw, being the systems of pressing of major diffusion in the antiquity. They are based on the lever principle known already in the Age of Iron.

Three types of levers exist according to the situation of the point of support with regard to the power and the resistance, levers being distinguished of first degree from the second and third degree.

These presses belong to the second degree and they are composed by a beam of wood that transmits the power exercised in an end on the grapes contained from diverse types of receptacles, placing the resistance finds in the opposite side.

During nineteenth century is employed at the model search that a major pressure and efficiency obtain.

This desire drove to realize a press that was multiplying the effort transmitted manually by the man, thus appearing the vertical press of leaned lever. It was not installed in the many wine places of the epoch but it was a model of advance, seeing in it a precedent of subsequent horizontal presses. It was used predominantly in Australia until the late nineteenth century. In 1835 there appeared the vertical presses of hydraulic cages: first oscillating, then mobiles on rails, finally with bench and mobile cages. They were rejected by 1955 [2].

The evolution led to construct a press of multiple Mabille lever type, existing multitude of presses of this type inside which there is the Samain press of double speed. It dates back from the first half of the twentieth Century and it will be the aim of study of this work.

In the middle of the nineteenth century appears the first horizontal press, thanks to which the current operating models are possible. Its evolution is the following one [3]:

1. In the second half of the nineteenth century, the first horizontal press appeared with a square and fixed wood cage.
2. In the first half of the twentieth Century, are introduced presses with cylindrical cages. They were made by Mr. Vaslín, providing a better pressure distribution.
3. Thus, the rotating cage arises; leaving the previous fixed cage obsolete and the Vaslin press types take the appearance of the current machines, showing major processes in a short period of time.
4. This kind of presses continued being constructed in accordance with the same principle but with the difference of which the drive of the gyratory cage press and press screws was obtained by means of a motor.
5. The reduction of the frame and substitution of the gear box by a pulley and gear seat.
6. Immediately afterwards the Cepdor presses appeared. It had a cylindrical cage that was spinning over a central threaded tree with a step to the right and to the left, object of study in this work.

A few years later, it appeared presses with a single plate of tighten, producing an automated shifting.

1.1 Engineering Graphics

The computing era has revolutionized all areas of human knowledge, being one of them the graphical representation. The technical sciences in symbiosis with the computer science have lead to the known as Engineering Graphics.

From prehistoric epochs, the human has used graphs, more or less artistic, to express his thoughts and the reality. Thus they were trying to communicate each other with their peers shaping ideas and objects.

In the Neolithic, signs and symbols are introduced, becoming more abstract the graphical expression. Thus arise the hieroglyphic and ideographic scripts and to the written languages of current alphabetical character.

Still in the nineteenth century, the words drawing and projection were considered to be practically synonymous; the outside contour of the drawing was considered as a projection.

Thanks to the discovery of the steam engine at the beginning of eighteenth century, the mechanical drawing differs from the architectural one, since in that epoch the drawings machines were similar to the used ones in the building.

Gaspar Monge created a new science, the Descriptive Geometry by means of the double orthogonal projection and with geometric simple procedures; it turned graphical dispersed technologies into an elaborated body.

The simplicity of the Monge System has done of the Descriptive geometry an instrument for the technical drawing and a suitable tool for the introduction to the Engineering.

In the emergence of computer graphics, the DAC-1 was one of the first CAD systems. It was used for the representation of vehicles, but the revolution of the Computer-Aided Design arises with the first commercial CAD about 1980. From here, there are arising versions that are used in diverse areas and that have been perfected up to coming to all the acquaintances at present.

In computer graphics, the computers are using for generating visual images as well as integrating or changing the visual and spatial information that provides the real world.

This work tries to study by static and dynamic way two presses of wine in disuse with the intention of communicating its operation in order to avoid the oblivion because they are a part of the history of production of the wine.

2 Wine Industry

The pressing in the vintage theory presents a static study based on the Pascal principle, and a dynamic study developed from Bernoulli's equation.

2.1 Static study

A press consisted of a pressure plate and a pressing cage (fig.1). A plate of pressure with a surface Sa receives a force Fa that produces a pressure.

This pressure is transmitted by the Pascal principle to the whole mass of vintage, escaping the must or wine from a surface Sb which corresponds to the sum of the drainage spaces of the cage.

$$P = \frac{F_a}{S_a} = \frac{F_b}{S_b} \quad (1)$$

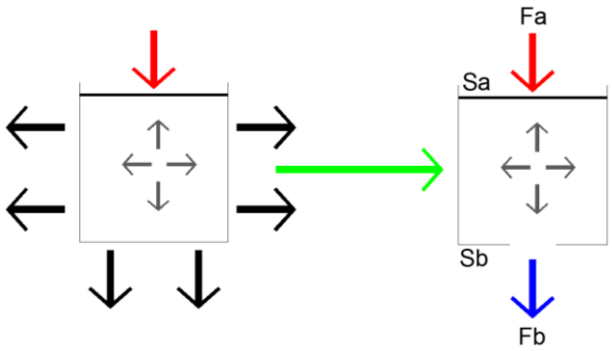

Fig. 1. Press with pressure plate and pressing cage scheme (Hidalgo Togores, 2011).

From these expressions, it is possible deducing that minor surface of drainage Sb, the force of extraction Fb is minor, agreeing a press that happens the opposite, it means, this surface must be as large as possible.

The drainage coefficient of a pressure cage, expresses the relation between the surface of drainage or open space (Sb) and the total surface of the same one (S). Being this value lower than an unit, better while more higher, and from 0,1 to 0,2 for the wood cages or from 0,2 to 0,3 for those of slotting steel [4].

2.2 Dynamic study

During the pressing process takes place the movement of the wine or must in its inside, it is possible to apply Bernoulli's equation.

In the model of the fig.2, the volume per unit of time that the pressure plate moves at a certain speed Va, it is equal to the volume of the must that goes out from the press cage to another speed Vb.

$$S_a \cdot V_a = S_b \cdot V_b \quad (2)$$

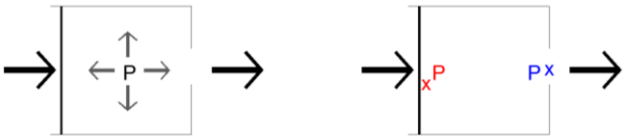

Fig. 2. Scheme Bernoulli's equation in a press (Hidalgo Togores, 2011).

When the relation between the surfaces of pressure and drainage Sa/Sb is raised, the output speed of the Vb must respect of that of the plate of pressure Va; happening the opposite when this one goes down.

Applying Bernoulli's equation between two points A and B of the press:

$$Va < Vb \Longrightarrow Pb < Pa$$

$$Va > Vb \Longrightarrow Pb > Pa$$

From this, it can be deduced that it is appropriate to arrange in the press a drained surface as high as possible, in order that the exit pressure is also as high as possible.

3 Methodology

The methodology followed in this study can divide in four stages:

3.1 Documentation

There has been performed a review of information across a wide bibliographical search of any document related to the presses used in the extraction of wine in general and more concretely of the vertical press of screw Samain type and horizontal press of two plates.

3.2 Capture of information

This second stage has been very useful to obtain the modelling of both presses, as well as to increase the knowledge on the wine presses. For that, it was necessary to realize several visits to the Cooperative "Nuestra Señora de la Aurora", where it still exist several vertical presses of screw preserve in a corner of its court of receipt of the vintage; Press of Santa Maria, place where a former warehouse was visited two vertical presses twice. The White Press, in whose inside is the horizontal press of two plates. All this is placed in Montilla's municipal area, province of Cordoba.

3.3 Design and shaped

Accomplishment of the design and shaped of both presses being studied by Autodesk Inventor Professional 2012, understanding for shaped the creation of a representation or image (the model) of a real object, being the aim to create a three-dimensional image.

3.4 Realist infographics and animation

Once concluded, it proceeds to fulfil the texturized, lighting, animation and placement of cameras, being fundamental all this inside the process, and on what depends the realism of the final result to a great extent.

4 Result and Discussion

Among the large quantities of vertical presses existing, this study will focus its attention on the vertical press of multiple levers, concretely the press called Samain of double speed, belonging to the group of presses of pressure for lever.

The Samain press of double speed is one of the systems of vertical presses that produce more pressure of that epoch, given the simplicity of his mechanism.

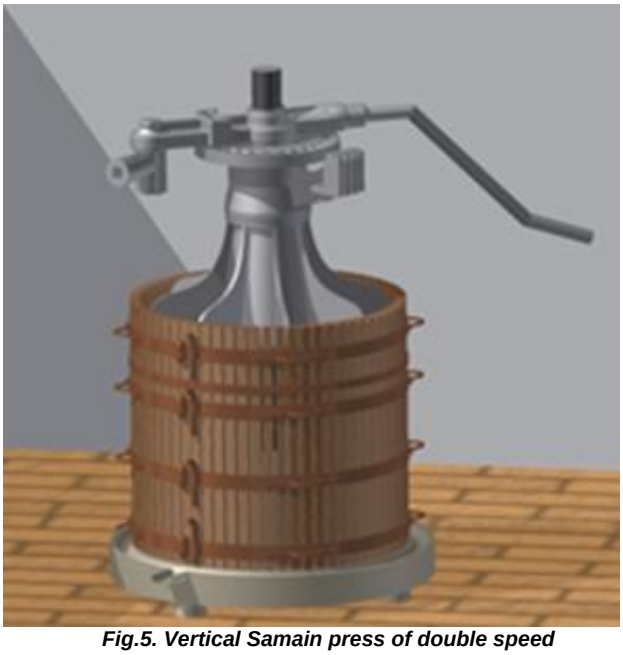

Fig.5. Vertical Samain press of double speed

The graphical engineering has helped to realize a geometric definition, simulation and animation, being of great help to understand the operation of these machines.

The parametric modelling is the aptitude to capture the design intent [6]. The parametric record catches the intention of the design to register what is done during the modelling process. It is very important to plan the development of the modelling to maximize the flexibility in the design intent.

In the method of parametric modelling, the steps followed to create the geometry are as important as its physical characteristics. It is necessary to analyze what you want to be done by the model. Consider which and how the dimensions and the characteristics of the design will change.

So this way, the correct assignment of geometric conditions and dimensions to the operations of modelling of shapes, so that the elements of the project remain connected in a logical form. It will make possible and simple any modification in the redesign since all the elements are related and they will get up-to-date.

Thanks to graphical engineering, it has led to the conclusion that the Samain press of double speed, although at first glance it could seem of a great simplicity, contains a great ingenuity in its movement and pressure. For his comprehension arrange her fig.3 and fig.4.[5]

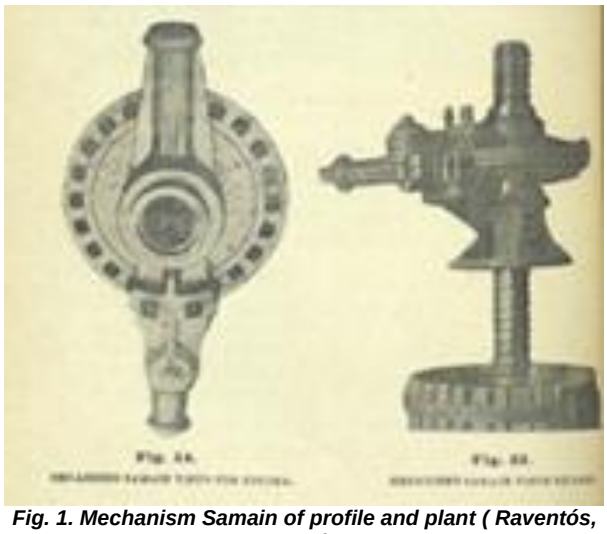

Fig. 1. Mechanism Samain of profile and plant (Raventós, 1905).

Fig. 4. Samain system (Raventós,1905)

The beginning of its operation after the discovery of red wine, due to the introduction of the residue produced in the cage of pressing. In white wines, it is realized before its fermentation. For that, the pressure plate must be as high as possible, fig.5.

Immediately afterwards, it is inserted the lever H in the G part and both bevel connectors in the same direction (O-O') in the tightening. A worker applies a force to the above mentioned lever to advance several steps and it returns to move back. Next, the socket wheel is turned to the right of the wheel (B) and the hat (E), getting down the plate of pressure (D) and exercising a pressure on the marc that is "proportional to the weight of the socket wheel and of its diameter" [5]. The wine is going out through the orifices of the pressing cage, settling in the crack that possesses the perimeter of the press base. On the contrary, when the operative moves back, the hat only rotates, being kept statically the socket wheel and the plate of pressure.

The bevel connectors are in charge of moving the socket wheel with a sway movement; by passing each time a hole of the nut that holds the wheel. Two are used and not an alone connector to be able to do the socket wheel with the half of diameter, which makes the whole press much more limited.

Once the pressure plate descends sufficiently, it proceeds to eliminate the top part of the cage of pressure to avoid hinder the last tightening. Then, the lever placed in the G part and the connectors make turn the hat an angle of 180º.

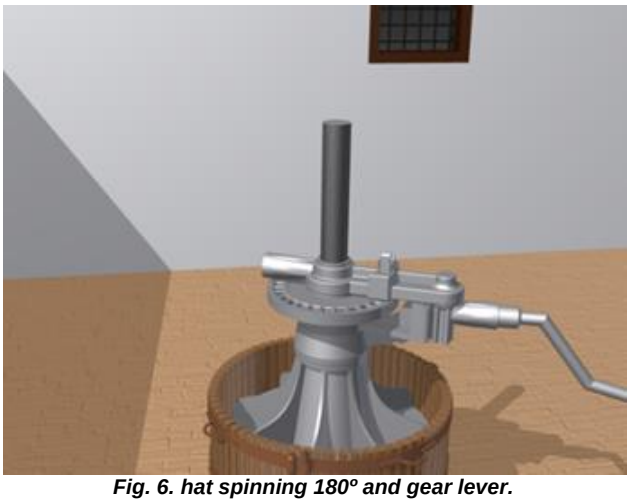

Fig. 6. hat spinning 180º and gear lever.

Then, the lever H gets in the G part, fig.6, and the connectors return to the hat in the same direction of tightening. The gear teeth having the pressure plate interact with the G part, producing major pressure to the last ones when the residue is too tightening.

Once squeezed the whole residue, it proceeds to the cleaning of the cage, moving the plate of pressure to his initial position.

According to the global productivity, the impact of the pressing in the wine production is very important since it needs rapid displacements of the grape and high pressures that carry the risk of crushing.

The pressing graph of the vertical press is an ascending line, where normally are applied three or four levels of pressure which are kept during a certain time before going on to the following step.

To increase the speed of pressing and the performances in the extraction, it is possible to interrupt the pressure periodically to crumble the compact mass of the vintage, initiating again the pressure up to reaching higher values than those of the previous period, and so on up to finishing the cycle of work. It is obtained an amount of must or wine of 2.000 litres / day, Table 1.

The study realized with regard to the mechanics of this machine leads to knowing the pressure applied by this type of press.

Two very different speeds are available according to the positioning of the lever in the Samain presses. The maximum pressure that they can reach in each of two stages where it is possible to arrange the lever for its operation.

The lever begins to move in the A part with both connectors in the same direction. The pressure produced in this movement is similar to the simple screw press. This question is a theoretical pressure as the screw press is a type of lever that multiplies extraordinarily the force, but it

has also a great friction. Its performance in effective force is around of 40 % [5].

Taking into account the friction, it is possible to calculate the practical pressure, in this way, the first movement produces a pressure of R = 0.24 N/mm^2 that it is a small quantity which will be increased by the intermittent system of working, making a return movement of the socket wheel and following with the advance.

The following movement occurs by placing the lever H in the G part, it is one of the most complicated works that presses can present. In this system, the point of support this axis To (fig.4), it means, the point in which the G part meshes with the plate of pressure. The pressure of the first lever is the power of the second one. The last lever takes the expression of the screw formula, obtaining a total pressure of 1.3 N/mm2 which multiplies by four the pressure exercised on the mass of the vintage.

To know the operation and the pressure exercised by the horizontal presses, it has also been used graphical engineering.

Above the chassis of the horizontal Vaslin press type, a fixed screw is supported oppositely threaded in its two halves. At each end a toothed wheel is disposed and, between them, it extends a series of strips forming the press cage provided with a door, through which the grape to be pressed is loaded.

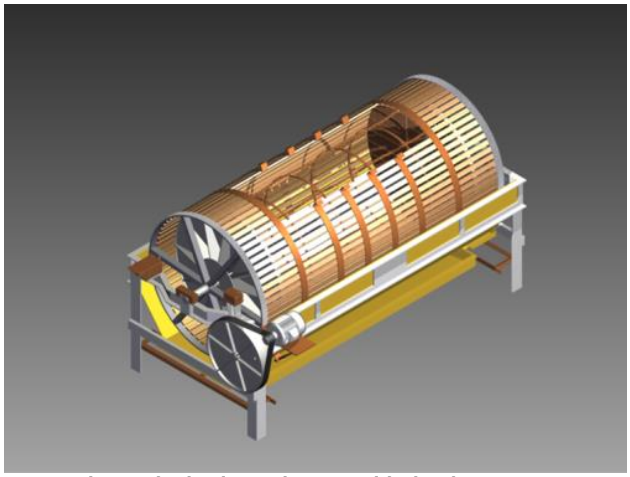

Fig. 2. The horizontal press with the door open.

Inside the cage, it is arranged two plates of pressure that are joined by means of chains connected by transverse responsible hoops of crumbled of the residue. These discs are threaded with the screw, so that according to the sense of the turn from the cage, the discs will approximate producing pressure on the mass of grape or they will move away.

The operation is obtained by an electrical engine, which is activated manually across a lever placed in the inverter box. The above mentioned engine stimulates a trapezoidal strap movement across the motive pulley.

The back part of the host pulley has reducer mechanisms that decrease the speed during the pressing. The exit axis of the reducer transmits the draft to two pine kernels that mesh with the toothed wheel and they make spinning the cage of pressing. The speeds to which the spinning cage are for example, of 1 rpm, having into account the different shifts introduced by the straps and pulleys.

The two pressure plates rotate with the cage due to the presence of notches which run through the rails of the cage. Simultaneously they are spinning, come closer or move away in one or another direction along the screw, pressing the mass of the vintage.

The pressing operation begins with the higher speed for a rapid initial approximation of the plates. At a determined pressure the reducer mechanism is driven manually by decreasing the speed. Once reached another major pressure point, this mechanism operates again, being able to invert the movement to separate the plates or to repeat this process several times.

The withdrawal of the must or wine is realized by means of a tray placed under the cage of pressing, with a point slope for to exit of the liquids by one of its ends.

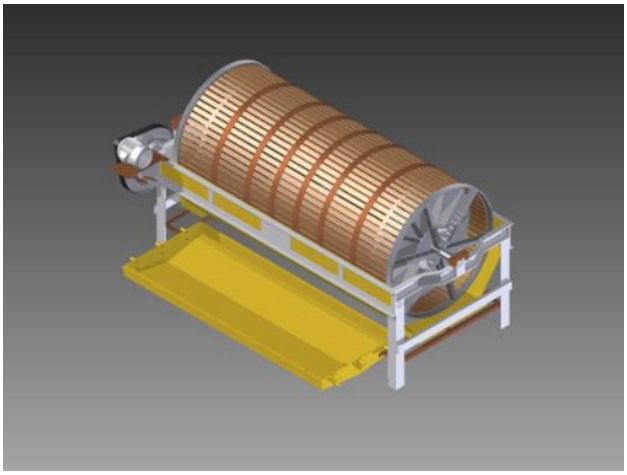

Fig. 3. Press emptying process.

During the empty phase of the press, fig.8, the pressing cage opens its door and the tray moves laterally across some rails, allowing the exit of the residues and the labours of cleanliness.

In the graph of this type of presses, it is observed how in the cycle of filling and the beginning of the pressing, the amount of extracted must is very high, decreasing progressively along the cycle up to leaving the dry and exhausted residues, being possible to applying increasing pressures. It is obtained a total of 36.000 litres / day, table1.

The horizontal press of two plates has a pressing that is realized in successive cycles of pressings and crumbled, increasing pressures in each of them, in such a way that the pressure of every cycle must be superior to than the previous one, reaching 0.9 N/mm^2 of maximum pressure, with a duration of about 3 hours.

Once calculated its screw spinning force, the maximum force of the pressure plate when the maximum pressure takes place shall be calculated by the formula (1), obtaining Fa's result of 950670 N.

Comparing the vertical Samain press type with its more direct competitor in the twentieth century, the horizontal press of two plates, it does not fit doubt of the great advance that supposed the latter with gyratory cage for the wine companies.

The following table shows the results obtained for both types of pressed:

	Applied pressure (N/mm^2)	Must or wine processed (l/day)
Vertical Samain press type	(The first position) 0.24	2,000
	(The second position) 1.3	
Horizontal press of two plates	0.9	36,000

Tab.1. Differences of pressures and processed wine.

Regarding to workability, the vertical press is loaded in two hours and a half, needing six pressure steps. This labour might be realized in 108 minutes if an intense work is realized. To do it, it is necessary to add an hour to unload the press, making a total of three hours and a half per pressed of six pressure steps. If it is added the time used to clean the press and the wine press (approximately one hour and a half), the total can be turn out to be 5 working hours [5].

In a 10 hours day two pressings are realized, it would be possible to increase to 3 pressed if they were not cleaned.

The horizontal press presents a work cycle much more limited, being the performance in must or wine higher but more loaded of turbid on having decreased the thickness of the mass of residue that they must cross.

The duration of a pressing cycle is approximately 3 hours, so what in a 10 hours day 3 pressed ones can be realized by its corresponding cleaning of the cage.

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