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Use of TRIZ method for innovation on new drying system of olive residues in olive oil industry.

Abdellatif LAJDEL[1], Mohamed MAZOUZI[1], Mohammed LAJDEL [1], Pr. Mina Bakasse [2]

[1] Laboratoire Contrôle et Caractérisation Mécanique des Matériaux et des Structures ENSEM, Université Hassan 2 Casablanca, MOROCCO

[2] UCD-FSJ-Laboratoire de Chimie Organique, Bioorganique et Environnement FSJ, Université Chouaib Doukkali El Jadida, MOROCCO

Abstract

With the use of eco-design standard and TRIZ method as combined approach we solve this problem and present an economic system as solution to recover the residues of the olive oil "olive cake" in view of their reuse in the energy and animal food. The design include the drying of pomace and pulp before storage for shipment to the recommended uses. This separation will be carried out in continuous mode in parallel with the existing production process.
In order to solve this problem of drying residues by considering constraints of the cost and the technical feasibility of solution without neglecting the environmental aspect we refer to and use TRIZ method.

Keywords: TRIZ, eco-design, COP, drying OC, eco-Innovation.

1. INTRODUCTION

The olive oil industry generates a significant amount of residues that impact not only the country but the entire planet by mainly polluting the soil. Their recycling is still partial for technical and economic reasons (Abdellatif LAJDEL el al. 2017).
However, in the majority of cases, the cost factor limits the use of these resources. Public pressure and environmental constraints are pushing governments to strike a balance between financial constraints and social pressure. In order to optimize costs it is important to implement a logistics system for an efficient collection; which can be managed by a local contractor or a power conversion operator.
In this study, we have begun a literature review on the history of sustainable development at global level, its evolution. We have highlighted the situations of developing countries in the face of environmental requirements. Indeed the main element is the emanation of CO_2 gas which represents an important factor in the impact on the planet. The usual drying for olive residues is based on the use of natural gas and therefore aggravating the environmental situation in this respect.
In addition it is imperative, with reference to the different protocol and COP to take into account the environmental aspect when drying the "Olive Cake" for the good of our planet and the good of future generations. Indeed for this purpose we will study and propose a solution with much less nuisance to the nature that surrounds us, in the following paragraphs.

The objective of this study is the use of TRIZ method to resolve this problem and propose an economic system to recover the residues of the olive oil "olive cake" in view of their reuse in the energy supply for the case of the pomace and in industry for pulp.

2. INTRODUCTION TO TRIZ METHOD

The industrial design activity is a key issue for the development of the company and society. The problems of innovation, environmental issues and sustainable development impose new constraints on manufacturers. Integrating the concept of sustainable development into current product design approaches requires the adaptation and evolution of existing tools and methods as well as the creation of eco-innovation tools. In the literature, there are various tools such as TRIZ tools, the eco-compass, the Product Idea Tree Diagram (PIT), the Quality Function Deployment (QFD) method, the Mind Map idea cards, and so on. Many authors analyze, critique and adapt these tools in order to develop an innovative and environmental design approach, (Jones et al, 2001), (Chen et al, 2003). Other approaches such as Kobayashi's proposal are to integrate eco-innovation concerns early in the design process. They plan to modify approaches to analyzing need and defining problem models, to develop innovation support tools and to define eco-efficiency indicators that can be used as much as possible, for example in level of concept choice (Kobayashi, 2006).¨

3. HISTORIC

The development of a Theory of the Resolution of Inventive Problems (French translation of the Russian acronym TRIZ) results from the work done by a Russian engineer, Genrich Altshuller (1926-1998). His status as an expert in Russian marine patents at the age of 20 was the trigger and starting point for his search for a method to facilitate inventive mechanisms and the emergence of inventions. After several articles and books bearing the beginnings of what would become his theory, the publication in English of the book: "Creativity as an exact science" in 1979 announced the birth of TRIZ. After 1986, Altshuller expanded his research beyond the technical fields into the basic sciences

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and pedagogy fields, aided by people who, since 1971, had been teaching and research institutions all over the world. -URSS, were involved in the evolution of the theory. The fall of the Soviet empire, and the expatriation of Altshuller's collaborators to the West, allowed TRIZ to take a new turn despite the death of the latter in 1998.

4. PROCESSUS PRESENTATION

In terms of the eco-innovative design process, Hsiang-Tang Chang and Jahau Lewis Chen (Chang et al, 2004), propose an approach based on technical contradictions of the TRIZ theory, associated with axes of eco-efficiency. This approach stems from previous research (Chen et al, 2003), defining a relation between the technical parameters of the TRIZ theory and the eco-efficiency axes (Desimone et al, 1997).

The eco-innovative design process proposed in Figure 1 (left-hand side) is divided into five stages:
1) Search for axes of eco-efficiency to improve. The choice of eco-efficiency elements depends on three scenarios. They explain that a design engineer can intuitively recognize, for a given product, the need to improve certain elements eco-efficiency. If not, he can classify the weight of each element eco-efficiency through the Analytical Hierarchy Process (AHP) (Saaty et al, 2000) or identify opportunities for product improvement through product life cycle analysis (LCA).

2) Research of technical parameters (Chen et al, 2003). By choosing an eco-efficiency axis, the choice of technical parameters is determined according to the weight of the eco-efficiency axis defined by the hierarchical analysis matrix (AHP).

3) Addition of necessary technical parameters according to the case study. These parameters are associated with the parameters chosen in the second step of the process, according to the contradiction defined by the designer

4) Resolution approach by contradictions:
a. If the problem studied defines a single contradiction, the resolution of the problem concerns only the principles of innovation associated with the contradiction.
b. If the studied problem defines several contradictions (parameters to improve and parameters not to degrade), the designer selects the principles of innovation according to their frequency of appearance for all the contradictions. The resolution of the problem is developed according to the principles of selected innovations.

5) Solution Ideas: At this stage of the process, it is a question of interpreting the principles of innovation related to the design problem studied.

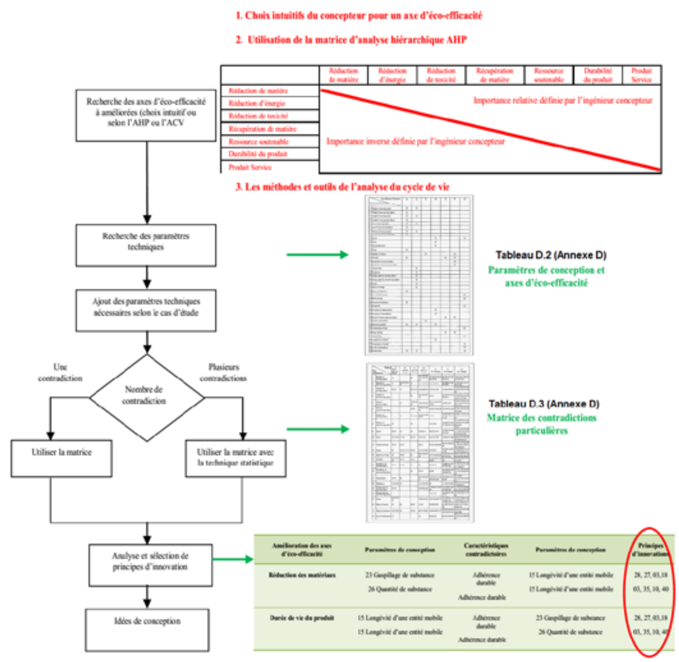

Figure1: Synoptic of the proposed eco-innovation process (Chang et al, 2004)

5. RESOLUTION BY THE TRIZ METHOD

5.1 IDENTIFICATION OF CONTRADICTIONSTESTS

The air flow tubular dryer is a new concept in drying technology. It is able to dry materials containing up to 95% moisture, the treated products can go from granules to powders. The flow rate of material through the dryer is controlled to obtain a fine dry powder or wet granular material.
On the other hand, this drying solution remains less economical in view of the losses of substances following the heating of the air necessary for drying the product. Both the drying temperature to which the blown air must be carried for drying in addition to the pressure at the burner to spray the fuel.
The energy consumption by the thermal drying plants (Figure 2) is very high, the investment cost is very important and the environmental impact is negative considering the quantities of CO_2 generated by this type of industrial process.

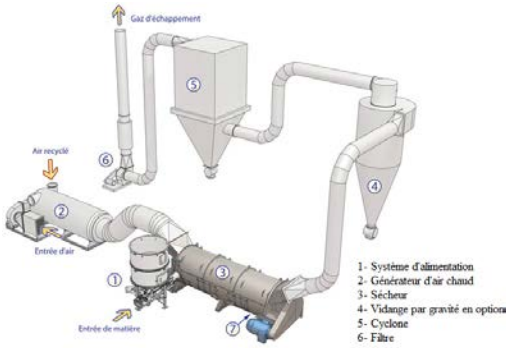

Figure 2: Tubular drying unit.

For our case, we note the contradictions of the TRIZ method with the elements mentioned in Table 2. Indeed we will treat four contradictions:

a) Temperature / Productivity
b) Power / Productivity
c) Loss of substance / Productivity
d) Ease of use / Productivity

Table 1: Correlation between design parameters and eco-efficiency axes.

→		Axes d'éco-efficacité						
↓	Paramètres de conception	Réduction de matière A	Réduction d'énergie B	Réduction de toxicité C	Récupération de matière D	Resource soutenable E	Durabilité du produit F	Produit Service G
17	Température		•					
21	Puissance		•					
23	Perte de substance	•		•				
33	Facilité d'usage						•	•
39	Productivité	•	•					•

Table 2: Evolution of design parameters.

Parameters that improve	*Parameters that degrease*
Temperature (17) Power (21) Loss of substance (23) Ease of use (33)	Productivity (39)

2.4.2 Results of the TRIZ matrix

The combination of the previously identified contradictions using the contradiction resolution matrix in Table D.3 (Appendix D) gives the result of the resulting innovation techniques (see Figures 3 to 6). These results are summarized in Table 3.

Table 3: Results of the TRIZ method

	Parameters that improve			
Parameters that degrease	Temperature (17)	Power (21)	Loss of substance (23)	Ease of use (33)
Productivity	15-28-35	28-35-34	28-35-10-23	15-1-28
	Innovation technics associated with combination			

a) Temperature / Productivity

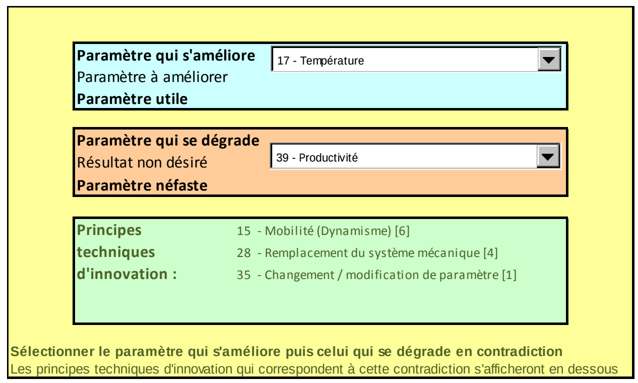

Figure 3: Technical innovation solution in combination of temperature and productivity contradictions

b) Power / Productivity

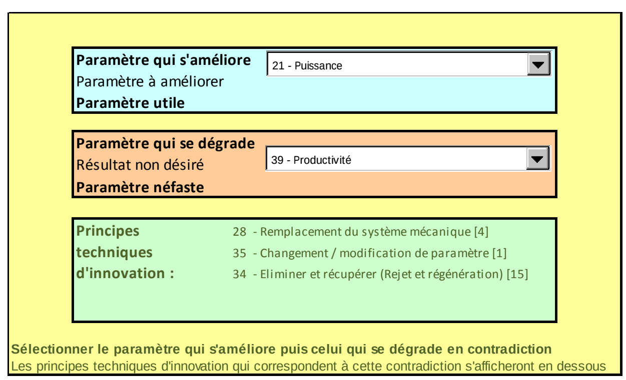

Figure 4: Technical innovation solution in combination of power and productivity contradictions

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c) Loss of substance / Productivity

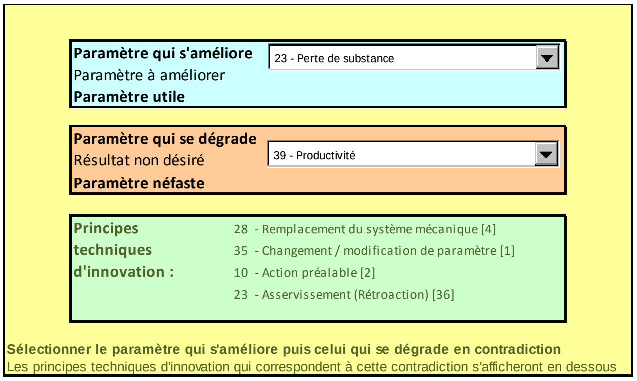

Figure 5: Technical innovation solution in combination of contradictions loss of substance and productivity

d) Ease of use / Productivity

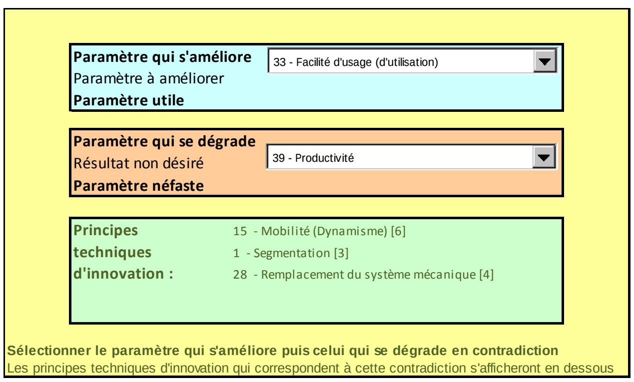

Figure 6: Technical solution of innovation in combination of contradictions facilitated of use (use) and productivity

2.4.3 Classification of innovation techniques

Since the problem studied defines several contradictions (parameters to be improved and parameters not to be degraded), the principles of innovation are selected according to their frequency of occurrence as indicated in Table 4.

Table 4: Classification of innovation techniques

Tools	weight (frequency of appearance	Major innovation technics choosen
28	4	Replacment of mechanical system
35	3	Change /change parameters
15	2	Mobility (dynamism)
34	1	Remove and recover
10	1	Prior action
23	1	Controlled system
1	1	Segmentation

5.3 Choice of innovation techniques

After describing all the innovation tools that can be adopted to develop a solution to our study, we will in this paragraph specify the most appropriate tools for our case.
In our case, tooling innovation techniques 28, tools 35 and 15 are well suited to our field of study. Indeed the tool 28, replace the mechanical system by a sensory system or use fields (electrical, magnetic, electromagnetic, etc.), the tool 35 (Change or / and parameter change), includes the aspect: Modify the physical state of an object (eg in the form of gas, liquid or solid). While the tool 15 (Mobility), stipulates the following concept: Allow or design an optimization of the characteristics of the object, the external environment or the process or find optimal operating conditions.

Referring to this tools and in order to solve this issue we focus on this parameters:

- •Temperature.
- •Loss of substance.
- •Power consumption.
- •Productivity.

Temperature parameter:
The question was why don't dry with low level of temperature?
- •Freezing.
- •Use Vacuum.

Loss of substance:
We develop question of recovering all substances by:
- •Condensate vapor.
- •Recover filtrate (liquid filtrate if using vacuum).

Power:
Choose system that consume less power:
- •Solar.
- •Vacuum.
- •Freezing.

Productivity:
The system that give more productivity and offer continues process is required for this application.

6. Discussion of last research:

Previous studies deal with the drying of residues by heat input or by centrifugation, the contribution of heat remains expensive even if it is the most answered process in several areas of drying products; Centrifugation is an alternative for drying. However, for olive residues, drying by vacuum is not treated. Our approach focuses on vacuum drying while studying the technico-economic feasibility with a view to designing an industrial process that can be used in the drying and separation of olive cake. We list hereafter major solution for drying residues:
1. Air drying heated from 80 ° C to 110 ° C.
2. Drying of a thin layer by infrared.
3. Innovative drying based on a fluidized bed.
4. Solar drying.
5. Dehumidification by centrifugation.

7. Perspectives &Conclusion

Based on the 4 design parameters not to be degraded (temperature, power, loss of substance, ease of use) and using the resolution matrix of the technical contradictions of the TRIZ theory, we were able to select the three principles of innovation which are tool 28, replacement of the mechanical system, tool 35, Change or / and modification of parameter, and tool 15, Mobility, the most favorable to guide our search for solution to our problem.
The subject of our innovation (research) concerns an innovative combination in order to make profitable and optimize the process of drying the residues which will be a source of energy and animal feed. It consists on a combination of drying by vacuum with option of drying by solar energy.
Environment: With drying by vacuum we avoid effluent that pollutes air; all chemical elements presents in olive cake are recovered on liquid and can be treated separately. (Abdellatif LAJDEL el al. 2017).
The process consisting in reducing the humidity of a high threshold of the order of 54% plus at least and on average at a threshold of less than 12% by an energy-saving and technically feasible system compared to the existing processes.
The use of TRIZ method can be combined with others methods to improve efficiency of results.

8. Innovation:

A patent was published on under WO/2016/163866 (Espacenet patent search), the aim of the invention is to design a cost-effective system for recovering olive-oil residue or "olive cake" that is intended for use in energy supply in the case of olive pomace and in the livestock industry in the case of olive pulp. The design comprises the drying, vacuum separation and, optionally, additional drying using solar energy of solid olive paste residue, which is subsequently stored in order to be shipped for the proposed uses. The separation is performed continuously in parallel with the existing oil production process.

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