PLC CONTROLLED , SMALL-SCALED OLIVE PRESS FOR HOUSEHOLD AND AGRICULTURAL RESEARCH UTILIZATION

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ABSTRACT

Our paper represents the design and implementation of full automated, PLC controlled small-scaled olive-press for household and agricultural research utilization. A prototype of the machine was realized in a frame of graduation project of students of Mechatronics engineering at Palestine Polytechnic University in Hebron. The paper includes a description of the control concept, the mechanical design and the application fields of such a press.

1. INTRODUCTION

Middle-east is the primary centre for olive in the Mediterranean basin. Olive is probably the most important agricultural product in Palestine. Olive tree cultivated areas account for more than 80% of the fruit trees area in Palestine, namely about 93,000 hectares [1]. Olive production plays a very important role in the Palestinian economy, and is used in many important local and regional specialties. According to Palestinian Central Bureau of Statistics, the added value of olive pressing activities totaled US$7 million in 2011[2].

Many households and small farmers have limited number of olive trees and reap yearly limited quantities of olives. Such small amounts would not be processed into oil by large presses because of economical reasons. However, many of these farmers are very interested to use these olives to extract even small amount of the relatively expensive oil.

A further important application of our press can be found in the agricultural research centers. Agricultural researches are often interested to investigate the quality of the olive oil of different types of olive, the effect of many factors like transport or storage conditions on the oil where small samples have to be processed.

To bridge this market gap we started to design and build a down-scaled olive press which is in its weight, dimension, and costs suitable for household utilization. We took into consideration the importance of safety and easiness of use hence such machines will probably be used by laypersons. A further advantage of our press is that and despite of modern control systems, the traditional method of olive oil pressing will be used which guarantees a high quality olive oil.

2. MECHANICAL DESIGN AND OPERATIONAL PRINCIPLE

After cleaning of olives the oil pressing follows mainly in three steps:

a) Milling which means breaking of the cells of the fruit and crushes them into paste which makes the extraction of the oil possible. The traditionally used milling methods are stone milling, hammer milling and disc milling. Figure 1 illustrates the three milling methods.

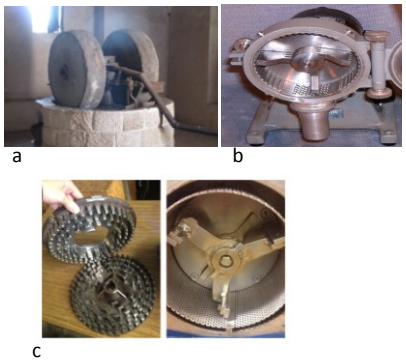

Figure.1: *Milling Methods: a) Stones Milling b) Hammer Milling c) Disc Milling*

b) Malaxition or kneading which aims to enhance the crushing process and make the paste uniform which yields into better extraction of oil.

c) Oil Extraction: In this final step the separation of oil from water follows. There are mainly three extraction methods:

- The traditional method which was used over 5000 years and still widely practiced hence it guarantees a high quality oil. The method is based on grinding of the olive paste on fiber discs which are stacked over each others. A pressure is then applied to the stack to extract the water-oil mixture.
- The Centrifugal Decanters which spin at high rotational speed (ca. 3000 rpm) and separates the heavy paste from the lighter water-oil mixture

Our prototype consists mainly two systems:

a) The Milling and Crushing System

This system contains the following components:

- For the milling process we decided to use an innovative method which is based on using two cylinders rotate against each others as shown in Figure.2. This method has the advantage of low cost and efforts in cleaning the machine.

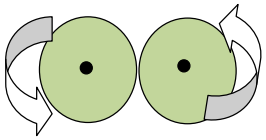

Figure 2: *The Milling Method Used in Our Machine*

- For the malaxation process we decided to use typical, electrically driven meat grinder which guarantees a slow malaxation at low temperatures (40 C-45C) at low costs. Low malaxation temperature is very important to prevent oxidation of the oil paste and yields into high quality oil.

- The separation method: crushed and kneaded paste lands then in a collecting system consisting of outer metal container with a smaller, inner filter cylinder to allow the seepage of the water-oil mixture to outer vessel (see in Figure. 3)

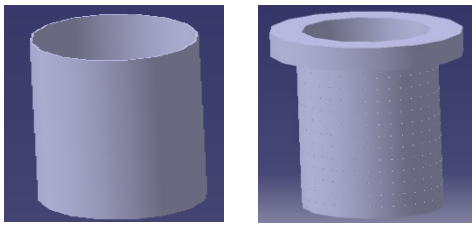

Figure 3: *Collecting System for the Paste: Outer Container (left) and Inner Filter Container (right)*

b) The Extraction System

After the olive fruit is milled and kneaded, the collecting vessel with the paste is then transported via conveyor to the extraction system in order to separate the oil from water.

The extraction system contains the following components:

- Pressing System: After the collecting vessels reach the extraction location a pressure is then applied to the paste to extract the water-oil mixture. The pressure is realized by a motor driven power screw and stainless steel plate fixed on its bottom. The screw used is a single threaded square power screw with a diameter of 16 mm and pitch of 2 mm. The pressing time can be adjusted by the PLC program.
- Extraction Unit: After the pressing process is completed, the extracted water-oil mixture is collected in a funnel. After specific time the oil will float on the top and can then be collected by the user.

The following figures show an overall schematic of the press and a photography of the real prototype

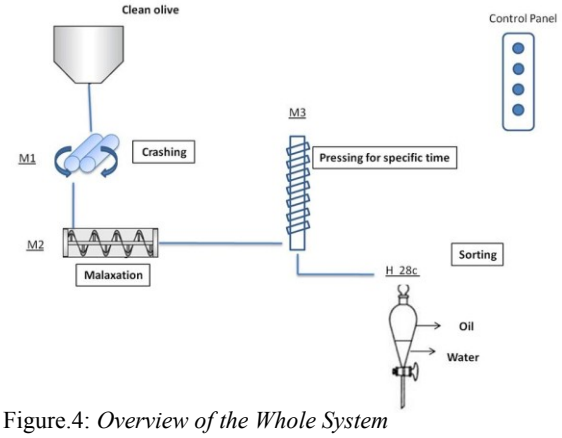

Figure.4: *Overview of the Whole System*

Figure 5: *Photography of the Real Prototype*

3. CONTROL CONCEPT

To automate the whole oil pressing process we used the programmable logic controller (PLC) S7200 from SIEMENS. The control program includes 5 outputs and 11 inputs which are described in Table1 and 2 respectively:

Table 1: *Required Outputs*

Output	Symbol
Motor1 for the crushing process	M1 (see FIG.4)
Motor 2 for kneading	M2 (see FIG.4)
Motor 3 for the pressure screw (Dual Direction Operation)	M3 (see FIG.4)
Motor 4 for the conveyor (Dual Direction Operation)	M4
Heater	K6

Table 2: *Required Inputs*

Input	Symbol
Light sensor to detect the presence of olives in the container	LM0
Selection switch to select between Manual or Automatic operation mode	S_s
Emergency Stop	EM
Limit switch to detect the presence of the collection container at the begin of process	LM1
Limit switch to detect if the containers with the paste has reached the extraction position	LM2
Limit switch to assure that the pressure screw is in the upper position	LM3
Limit switch to assure that the pressure screw has reached the lower position	LM4
Temperature sensor to heat up the water-oil mixture till 30 C	BT
Push button to start motor1 (crushing motor) in case of manual mode	Sm1
Push button motor2 (kneading motor) in case of manual mode	Sm2
Push button to start motor3 for the conveyor in case of manual operation	Sm3

The control program assures the following process procedure :

- At the begin, the user has to select between Automatic and Manual operational mode using the selection switch S_M.

If the Automatic mode is selected:

- In case of presence of olives in the container (detected by LM0) the crushing process begins (Motor 1 on)
- After all fruits in the container are crushed , the crushing motor M1 stops and the kneading motor M2 starts
- After a free adjustable time T1 is over the kneading motor stops and the conveyor rotates to the right using Motor 4
- Once the extraction position is reached (detected by limit switch LM2) the pressure screw is driven down by switching Motor 3 on
- Once the pressure screw reaches its lower limit, the screw is driven up by switching Motor 3 in the opposite direction.
- Once the pressure screw reaches its upper position again, a heater is switched on till the temperature of the water-oil mixture reaches 30 C

In case of manual operation, any of the above steps can follow independently by pressing on the respective switch.

The process can be again described using the state graph method [3] where the process is divided into states. A box represents the number of the state and the actions active in this state are described while the text at the top of the state represents the condition to be fulfilled to leave the state to another one. We will limit the state graph mainly at the Automatic Operation Mode.

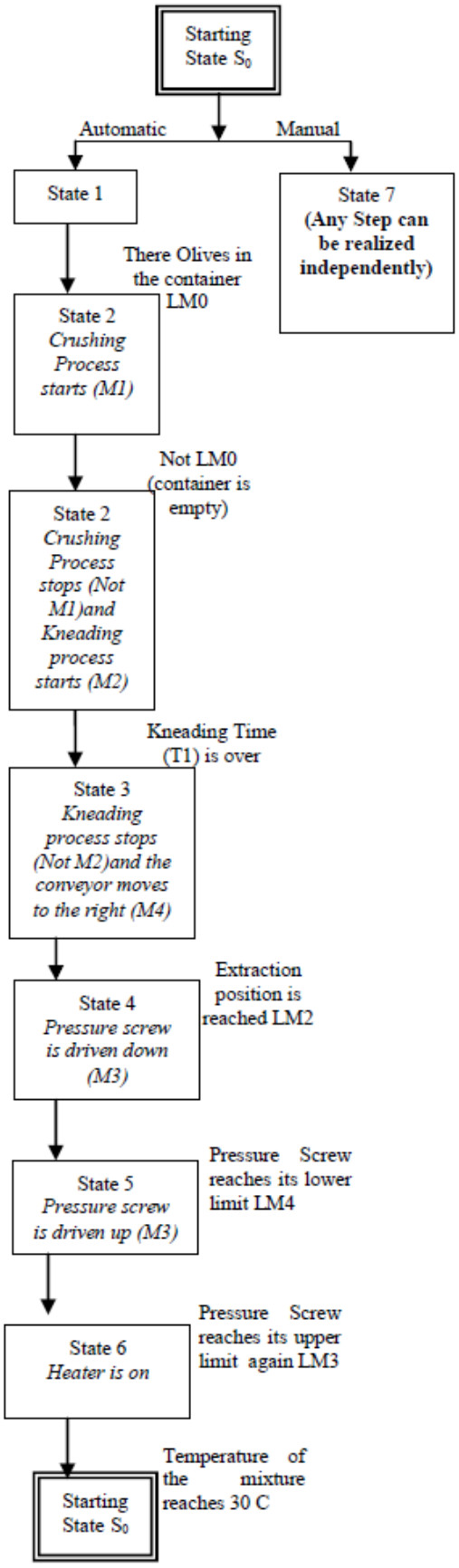

Figure 6: *The Control Concept as State Graph (Automatic Mode*

It is important to notice that pressing on the emergency push button EM would stops all active actuators an at any time.

4. CONCLUSION AND FUTURE VISION

A prototype for fully automated small-scaled olive press for household and agricultural research use was designed and implemented. The pressing concept guarantees a high quality oil hence the steps of the oil extraction follow at low temperature and slowly.

The team has started to develop the press to be suitable for pressing further products like grapes, sesames, etc. which increases the economical efficiency of the press. The team is currently in negotiation with interested investors to start serial production of the prototype.

The project has won several prices like the first price of the 3rd Students Innovation Conference organized by Palestine Polytechnic University in Hebron and the price of the national innovation forum in Palestine .

5. REFERENCES

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[2] Palestinian Central Bureau of Statistics, Press release on Olive Press Survey in the Palestinian Territory, 2011

[3] L. A. Bryan, E. A. Bryan, "Programmable Controllers, Theory and Implementation