ABSTRACT

Keywords: *winemaking, wine equipments, simulation CFD, optimization*

The doctoral thesis entitled "**Research on working processes optimization for the main equipments from the structure of technological lines of primary vinification and wine conditioning**" aims to optimize the working processes of some equipment used in the grapes vinification.

The work is structured in two parts, "***State of knowledge***" and "***Own contributions***", made up of seven chapters with a total of 190 pages, 37 tables, 107 figures, 116 mathematical relationships and 95 references titles. The first part of the paper refers to the current state of addressed knowledge issues, including the introduction and two chapters, and in the second part are presented the own research structured in three chapters followed by conclusions and references.

In the **first chapter** are presented aspects regarding the importance of wine technology, information that refer to primary vinification and wine conditioning technologies, but also the current status on the primary vinification and wine conditioning technological line structure. Also, are found the current trends of the wine equipment construction. In this chapter are described the representative equipment, on each operation, used in the wine industry, taking as reference the wine technological flow.

Chapter II, entitled "*Theoretical basis of work processes of specific equipment for the primary processing of grapes and wine conditioning*", is composed of three chapters that refer to the working process of grapes crushing – destemmer equipment, of must separation equipment form marc and of the solids filtration wine equipment.

The part with the own research starts with **chapter III** „*Purpose and objectives of the doctoral thesis”*. To accomplish the general objective are propose the following ***specific objectives***:

- carrying out the bibliographic study on the winemaking technologies, the existing technological lines and the equipment used in primary vinification and wine conditioning;
- study of the working process theoretical basis of some equipment used in grapes primary vinification and wine conditioning;

- design and realization an experimental stand for centrifugal field sedimentation and solid particles filtration in must and wine;
- develop an experimental plan that will accomplish the research proposed in the thesis;
- research on mathematical modeling through CFD simulations of the hydrocyclone working process;
- research on mathematical modeling through CFD simulations of the hydrocyclone working process, on which were made constructive geometric changes;
- experimental research on the optimization the equipment working process by variation of some specific parameters for the must extraction, of white and red grapes, by pressing, and for the separation particle from must, using a special construction hydrocyclone, and from wine, by using a filter plates;
- elaboration of some conclusions and recommendations on the working process optimization for the studied equipment.

Within **chapter IV** - *Material and method of research* - are presented the organizational and institutional development of research, the raw material and its origin, the experimental protocol, then is make the description of equipment, installations and devices used in the experiments.

The researches were performed in the Wine Station and Enology Laboratory from the Experimental Didactic Station "Vasile Adamachi" Iasi and in the Food Industry Equipment Laboratory, Faculty of Agriculture, University of Agricultural Sciences and Veterinary Medicine "Ion Ionescu de la Brad" of Iasi, in the period 2011-2013.

Within the experimental research were used wine grapes harvested in the area of Experimental Didactic Station "Vasile Adamachi" Iaşi which is part of Iasi Vineyards. The harvested grapes belong to the following vine varieties: Aligoté, Fetească albă, Fetească neagră and Merlot.

The experimental protocol envisages organizing experiences to fulfill the purpose and objectives in the thesis.

In this sense, were established three stages of development of the experimental protocol:

- experimental protocol organizing to optimize the must extraction work process by pressing;
- experimental protocol organizing to optimize the coarse solid particles separation work process from must by centrifugation;
- experimental protocol organizing optimization work process of fine particle separation from wine by filtration

Depending on the studied working process, the experimental variations were noted with **V** + vine variety name initials (Aligoté-**A**, Fetească albă-**Fa**, Fetească neagră- **Fn**, Merlot-**M**) + used equipment initial (press-**P**, hydrocyclone-**H**, filter plate-**F**) + version number.

Each variant was developed based on the parameters that were determined for each experimental protocol basis.

In order to optimize the must extraction process through pressing it settled 27 variants for each variety, denoted as follows:

- for variety Aligoté - from VAP1 to VAP27;
- for variety Fetească albă - from VFaP1 to VFaP27;
- for variety Fetească neagră - from VFnP1 to VFnP27;
- for variety Merlot - from VMP1 to VMP27.

For optimizing the working process of coarse solid particles separation from must by centrifugation, have been established 33 variants for each white grape variety and 24 variants for each red grape variety, denoted as follows:

- for variety Aligoté - from VAF1 to VAF13;
- for variety Fetească albă - from VFaF1 to VFaF13;
- for variety Fetească neagră - from VFnF1 to VFnF13;
- for variety Merlot - from VMF1 to VMF13.

After establishing the experimental variants, in the chapter were presented the devices, equipment and installations used for the experimental research: crushing – destemmer, grapes pneumatic press, laboratory stand for separating solids in centrifugal field and filter layer, hydrocyclone, filter plates, electronic scales, roman balance scales, Zeiss hand refractometer, Turb 555 turbidometer and TYAN graphics station.

In the **chapter V** entitled "C*ontributions regarding mathematical modeling of working process of hydrocyclone by CFD simulation* ", is structured in three sections. The first chapter has described the process work of the hydrocyclone, followed in the second chapter to realize the working process mathematical modeling. Here, the processing results are presented as the speed field, the Reynolds turbulence, power lines, and that the trajectory the particles, the more their dimensions. The purpose is to identify the size of the particles separated in the hydrocyclone and the way of evolution of these particles in correlation to the turbulence of the must in the browsing of the hydrocyclone input to the output.

Representing the velocity field shows a growth rate higher body must prevails field centrifugal forces with increasing input must flow, and lower body speed is maintained at a low level for the three debits introduced in the simulation.

In simulation CFD, the program FLUENT can report overall efficiency by the ratio of the number of particles of the same diameter trapped in the purge line and the total number of particles injected into the hydrocyclone.

By knowing the injected flow rate particles, the diameter and density of particles, FLUENT calculates the number of injected particles, and the simulation as proposed mathematical model (DPM) resulting number of particles trapped in the drain pipe. By difference can be obtained and the number of particles that are released along with wine.

Experimentally, the separation degree is obtained by measuring the must turbidity when entering the hydrocyclone and discharged at the hydrocyclone. Subsequently, the must samples both the inlet duct and the outlet of the hydrocyclone, for different flow rates, are introduced under the microscope to determine the distribution of class sizes (diameter) of the particles. Through difference is obtained the number of particles of a certain diameter of the purging duct. Data presented graphically as grade separation for the experimental values, take into account the number of particles retained in the purging duct what is reported in the total number of particles of the same diameter injected into the hydrocyclone.

Following these simulations it was found that at the must supply flows of Q_2= 0,488 kg/s has done the best particle separation of must, than the other two supply flows simulated respectively Q_1= 0,358 kg/s and Q_3= 0,531 kg/s.

It was also shown that the particle separation of less than 100 µm was not possible so that it demonstrates that this hydrocyclone is appropriate for removing coarse particles in the must (such as high volume burbele which has a negative influence on the quality of wine).

In subchapter three have conducted research on hydrocyclone geometry optimization through CFD simulation by modifying the geometry of the hydrocyclone.

In the first case, the simulations were done in order to optimize the length of the clarified must evacuation duct (L1) to supply the minimum flow rate must Q_1= 0,358 kg/s and the maximum supply debit the must Q_3 = 0.531 kg/s for particles with a diameter of 100 µm.

In all six experimental variants showed that however were short evacuation duct must clarified would not be possible to be involved particles equal to or of less than 100 µm.

In the second case, simulations were undertaken to optimize the process work of the hydrocyclone by doubling the sedimentation height of the lower body (L_3 = 0.27 m) than initial height (L_3 = 0,135 m) so as to be able to separate a higher percentage of particles of 100 µm. The introduction of a must supply debit by Q_3 = 0.531 kg/s the simulations it was observed that the particle reaches the purge connection resulting in that the geometric form is optimal to remove the particle size of 100 µm.

In the first case, the simulations were done in order to optimize the length of the clarified wort outlet pipe (L_1) to supply the minimum flow rate must Q_1 = 0.358 kg/s and the maximum supply flow rate must Q_3 = 0,531 kg/s solid particles with a diameter of 100 µm must. In all six experimental variants was determined that whatever would shorten the outlet pipe must cleared, it would be possible to be involved solids equal to or less than 100 µm.

In the second case, the simulations were carried out to optimize the work of the hydrocyclone, by doubling the settling height of the lower body (L_3 = 0,27 m) to the original height (L_3 = 0,135 m) so that to be able to separate a higher percentage of solid particles of 100 µm.

A further case study has been doubling of the diameter of the hydrocyclone body sedimentation (d_3 = 0,322 m) from the original diameter (d_3 = 0,161 m). Simulations were carried out by introducing a feed rate must Q_3 = 0,531 kg/s of solids with a diameter of 100 µm, for the same reason to achieve a high degree of separation as.

In the latter case, by attaching to the hydrocyclone geometry as a truncated cone at the lower discharge pipe part of the clarified wort. To simulate the working process, used three different flow rates must supply (Q_1 = 0,358 kg/s, Q_2 = 0,488 kg/s, Q_3 = 0,531 kg/s) and if it is intended to improve the degree of separation of solid particles diameter between 100 µm and 2000 µm.

In **Chapter VI**, entitled "*Experimental research on determining and improving operating parameters of equipment for primary processing of grapes and wine conditioning*" the results of research that contributes to optimizing work processes of vertical pneumatic grape press, the hydrocyclone filter plates and filter.

Based on experimental results obtained after extraction must press was established best option for every kind of vine experienced this: Aligoté variety VAP18 version ensures the highest yield in wine (77,65 %), the Fetească albă established VFaP18 version (78,53 %) for Fetească neagră is VFnP12 version (81,82 %) and Merlot is the best option VMP12 a yield of 79,94 % must press.

The analysis of experimental data on the separation process optimization work must coarse solids by centrifugation, it was found that the optimal flow of the hydrocyclone feed must be Q_2 = 0,488 kg/s. At this feed rate is obtained turbidity of musts falling within the limits recommended by the literature, so that must be performed as required oenological Settling. Flow rate 0,488 kg/s available for all types of solid particles must undergo separation.

Experimental variants flow of the hydrocyclone feed is 0,488 kg/s, are:

- for Aligoté variety: VAH2, VAH5, VAH8, VAH11, VAH14, VAH17, VAH20,

VAH23, VAH26, VAH29 and VAH32;

- for Fetească albă variety: VFaH2, VFaH5, VFaH8, VFaH11, VFaH14, VFaH17, VFaH20, VFaH23, VFaH26, VFaH29 and VFaH32;
- for Fetească neagră variety: VFnH2, VFnH5, VFnH8, VFnH11, VFnH14, VFnH17, VFnH20 and VFnH23;
- for Merlot variety: VMH2, VMH5, VMH8, VMH11, VMH14, VMH17, VMH20 and VMH23.

Following the analysis results presented in the workflow optimization of the separation of solid particles from wine by filtration, the pressure difference Δp was determined for different filter plates in terms of the filtration degree, we can say that for the coarse filter of the filtration the optimum value of Δp is 0,07 MPa, for the fine filter plates the optimum value of Δp is 0,06 MPa and for the sterilizing filter plates the optimum value of Δp is 0,05 MPa. It was also found, that filtered wine turbidity varies similarly for all four grape varieties studied.

The thesis was completed with a series of conclusions and recommendations that highlight the most important aspects of the undertaken results of research.