THE NEW SOLUTION OF THE SUBSTANCE FLOW SYSTEM IN THE STEAM DISTILLATION PROCESS OF ESSENTIAL OIL

PhD Dobrnjac M.[1], PhD Hodžić A.[2], MSc Dobrnjac S.[3], Dobrnjac D.[4]
Faculty of Mechanical Engineering, University of Banja Luka, Bosnia and Herzegovina[1]
Faculty of Technical Sciences, University of Bihac, Bosnia and Herzegovina[2]
Projekt JSC, Banja Luka, Bosnia and Herzegovina[3]
Solar mont Ltd, Gradiska, Bosnia and Herzegovina[4]

mirko.dobrnjac@mf.unibl.org, atif.hodzicc@gmail.com, sanjadob@gmail.com, solarmontdoo@gmail.com

Abstract: *The steam distillation is the most frequently method for production essential oil from fresh medicinal and aromatic plants. This paper compares an existing with an innovative solution of the substance flow system which is used for production essential oils from the biomass of lavender, juniper, immortelle, chamomile, etc. In order to improve the effectiveness of the distillation process as well as the quality of extracted essential oils, most often used substance flow system was reconstructed. The existing solution of distillation equipment was improved with two innovations. The first one refers to the supply of steam from upper side into the distillation unit, and the second is the technical solution of the condenser. The new distillation equipment was produced in domestic company, and analysis of produced essential oil from immortelle was compared with oil produced with classic distillation method. The analysis showed the improvement of the quality of the essential oil produced with new distillation unit.*

Keywords: STEAM DISTILLERY, SUBSTANCE FLOW, ESSENTIAL OIL, RECONSTRUCTION, PROCESS EFFICIENCY

1. Introduction

Medicinal and aromatic plants have been used for centuries in phytotherapy or like spices, but their current use is far wider. The relatively large number of sunny days, favourable climate, unpolluted air and soil in Bosnia and Herzegovina are particularly suitable for the cultivation and growth these plants of high quality. This fact requires the development of appropriate processing procedures and equipment. The most widespread level of processing is drying, but far more useful and profitable products were obtained by the distillation of aromatic plants. For our region, on which it is usually processed fresh plants like abies, lavender, chamomile, immortelle, mint, basil, oregano,... the most appropriate method is the steam distillation. Producers and processors of medicinal and aromatic plants is necessary to be educated in terms of distillation technology. Also, the good quality of equipment for obtain a better quality and larger quantities of essential oils are provided them.

Many years of experience in the distillation of essential oils, in terms of technical and technological improvement of equipment for distillation, resulting in a new solution for the flow of useful substances from the plants. Certain critical points, identified as potential causes of reduction of the quantity and quality of the final product were removed by using new solution.

2. Reconstruction of the substance flow system

During distillation produced steam passes through the plant material, softens it and extracts useful components of essential oils. The resulting vapor mixture is condensed and cooled, and as a result is obtained a aromatic liquid mixture with essential oil on the surface. Working for many years in the design and production of equipment for steam distillation and comparing parameters of the distillation process on different technical solutions, it was concluded that the basic mistakes that are repeated, following:

- low quality of produced essential oils, with unnatural colors or bad composition,
- traces of rust or other impurities in oil,
- low efficiency of the process.

Disrupted oil quality could be primarily due to retention of residual products from the distillation in the narrow parts and pockets in system for distillation and condensation occurring due to poor geometry of circulation system.

Key critical phases in the process are:

- the introduction of produced vapor in the fresh plants and
- condensation of aromatic mixtures.

Technical-technological solution of these phases implementation directly influences to the quality and quantity of produced essential oils, consumption energy for steam production, as well as a great consumption of cooling water, which is very important from the standpoint of process efficiency. Reconstruction of existing systems for distillation was carried out taking into account these factors and in order to improve the output parameters. Changes were made to the inlet of water vapor in the biomass, as well as the construction of condenser.

In a typical distiller for the steam distillation, the plant material is heated from the bottom by injection of heat, release of steam through the nozzles in the zone below the plant material (Figure 1). Wherein the water vapor is flowed in the direction from the bottom upwards. It is obvious that here is a problem due to the opposite direction of the water vapor and the condensate which is partially from the plant mass.

Fig. 1 *Injection of steam from the bottom - typical distiller*

Fig. 2 *Supply of steam on top of the distiller - new solution of distiller*

The vapor, in the new solution of the distiller, was introduced from the upper side, and the flow of steam through the biomass has a direction from top to bottom (Figures 2 and 3), opposite to the current technical solution. This provides a more uniform dispersal of the vapor phase in the plant material and approximately the same temperature. In this way is achieved a more spontaneous thermal treatment process of the plant material, less retention of the condensate in the plant mass and supplying "fresher" dry-saturated water vapor, which speeds up the process of distillation. It avoids also the possibility of poor quality oil production due to prolonged or inadequate heating the plant material in the distiller. This solution also avoids closuring nozzles for steam supply with the plant material, which increases the energy consumption and eliminate the delays in the process.

Fig. 3 *The upper part of the distiller*

After distillation, another very important phase is condensation of mixture of essential oil with water vapor, which occurs in the condenser. It is necessary to ensure the efficient and optimal operation of the condenser that condensation process completed by the end completely and without excessive retention of vapor phase and the condensate. Too long retention of the mixture in the condenser results in the accumulation of essential oils on the condenser walls, which affects to the purity and the amount of produced oil. Some of the technical solutions of the condenser can retain the condensate formed in the prolonged contact between the material of condenser and active substance, which results in poor quality. On the other hand, too fast process with incomplete condensation causes quantitative loss of essential oils. All impurities resulting from the process directly affect to the quality and visual acceptability of essential oil.

The previous technical solutions of condenser were mainly composed of disc-shaped surfaces (Figure 4), or in the form of a spiral pipe (Figure 4). Both solutions have their disadvantages, mainly due to the existence of a small diameters or flat surfaces that retains the essential oil, changing its natural properties and loosing quality.

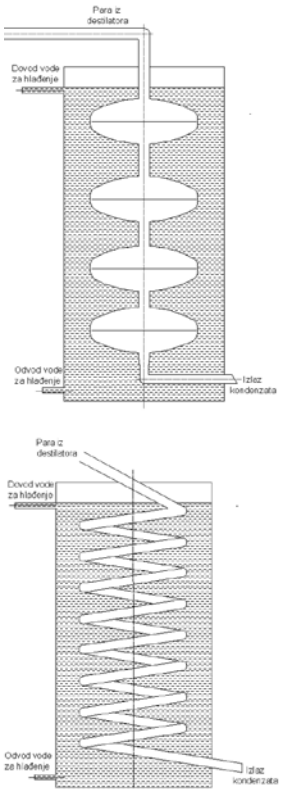

Fig. 4 *Previous technical solutions of condenser*

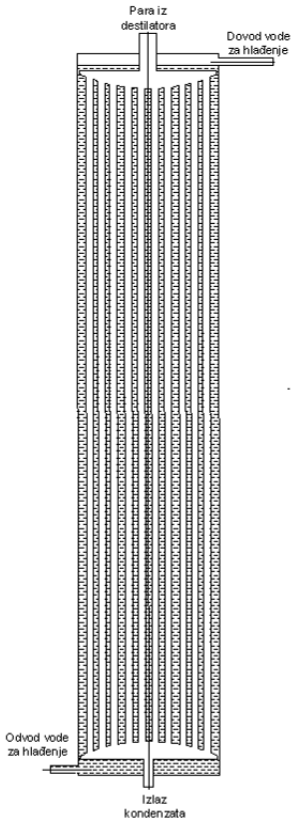

Fig. 5 *New solution of condenser*

The new solution of the condenser (Figure 5) is designed as a vertical tube heat exchanger with a flat tubes which have a relatively small diameter in relation to the length. Its advantage is that it is not possible to retain condensate in the pipes that simply flows down the vertical pipe cooled by the cooling water. These tubes do not have bottlenecks, coils or horizontal sections, with possibility to retain condensate. In this way is achieved a more efficient process, the complete condensation in the minimum period of time and with minimal contact of steam and liquid phase with the wall of condenser. Condensing and cooling of condensate in this condenser requires significantly less water, which in the financial balance of essential oil production is an important item.

The application of these technical solutions has been reduced the duration of the distillation for 10-15%, and the resultant is a larger quantity of essential oil 2-3%, depending on the type of plant mass. The resulting oil is crystal pure color and exceptional quality from the standpoint of scents and organoleptical properties. By monitoring the consumption of energy has been observed a decrease of 5%, while the quantity of cold water necessary for the condensation of the vapor phase is reduced by as much as 20%, resulting in significant economic savings, as well as advantageous from the preservation of natural resources, environmental protection and sustainable development.

Fig. 6 *Complete equipment for essential oil distillation with new solution of the substance flow system (produced by "Solar mont" Ltd, Gradiska, B&H)*

3. Analysis produced essential oil

Essential oils are a mixture of different chemical compounds. Most they include compounds of carbon, hydrogen and oxygen, to a lesser extent compounds containing nitrogen and sulfur. Characteristic properties of essential oils, as well as their quality and price, to a large extent depend on their chemical composition.

Table 1 shows the results of analysis the chemical composition of immortelle (*Helichrysum italicum*) essential oil, produced in standard distiller and in a new technical solution of distiller. Analysis, carried out on a gas chromatograph (*Institute of Medicinal Plants "Josif Pančić" Belgrade*), shows that the key components, responsible for the quality of the essential oil, are more represent in the sample produced in a new technical solution of the distiller. Based on the organoleptic and physico-chemical properties, this essential oil can be classified into high quality oils, with pleasant smell and authentic natural geographic features. The results are encouraging us for further development of equipment and processes, seriously organize domestic production and marketing of essential oils on the world market.

Table 1: *The chemical composition of the immortelle essential oil*

Composition	Standard distiller, %	New solution of distiller, %
α-pinene	25,14285	25,26783
camphene	0,54325	0,62729
β-pinene	0,43095	0,45586
β-myrcene	0,08179	0,07541
α-phellandrene	0,04627	0,04211
α-terpinene	0,14408	0,15283
p-cymene	0,21121	0,19813
limonene	2,75325	3,11092

1,8-cineole	0,52215	0,50174
α-terpinolene	0,19311	0,21085
linalool	0,54509	0,64262
terpinene-4-ol	0,21098	0,23693
α-terpineole	0,33410	0,44070
nerol	0,43875	0,59131
neryl acetate	5,22900	5,78116
α-copaene	2,84192	2,89870
neryl propionate	0,70436	0,79003
γ-curcumene	14,46259	15,51261
γ-cadinene	0,80794	0,80726
δ-cadinene	1,10583	1,07623

4. Conclusion

Production of medicinal and aromatic plants and essential oils from them on the territory of Bosnia and Herzegovina reaches a commercial level. Research in the field of training equipment for the production of essential oils are therefore justified. Reconstruction of the standard distiller has resulted in shorter duration of distillation and higher amount of essential oil. Due to a shorter treatment time and more balanced allocation of the vapor phase in the distiller, oil has crystal pure color and exceptional quality from the standpoint of scents and organoleptical properties. The consumption of energy are decreased, but also the amount of water necessary for the condensation vapor phase, due to the optimization of technical and technological characteristics of the condenser. Reconstruction has made a positive impact, in terms of essential oil quality, energy savings, but also in terms of preserving natural resources and protecting the environment.

By analyzing the chemical composition of the immortelle (*Helichrysum italicum*) essential oil, produced in standard distiller and in a new technical solution of distiller and condenser can be concluded that the key componentsw responsible for the quality of essential oil more represent in the sample produced in a new technical solution of the distiller.

5. References

[1] Jančić, R., Stošić, D., Mimica-Dukić, N., Lakušić, B., *Aromatične biljke Srbije*, Beograd, Gornji Milanovac, NIP Dečje novine, 1995.

[2] Franistyn, H., *Handbuch der Kosmetika und Riechstoffe*, Heidelberg, 1969-1973.

[3] Stepanović, B., *Proizvodnja lekovitog i aromatičnog bilja*, Beograd, 1983

[4] Dobrnjac, M., Vučić, N., *Pokazatelji probne proizvodnje etarskog ulja iz iglica jele (Abies Alba) metodom parne destilacij*e, Procesna tehnika (16), Beograd, 2-3/2000, str.190-192,

[5] Stepanović B., Radanović D., Šumatić N., Pržulj J., Todorović J., Komljenović I., Marković M., *Tehnologija proizvodnje ljekovitih, aromatičnih i začinskih biljaka*, Zavod za udžbenike i nastavna sredstva, Beograd, 2001

[6] Lawless, J., *Essential oils Element*, Shaftesbury, UK, 1995