# RESEARCH ON EFFICIENCY HEAT EXCHANGER WITH POROUS MEDIUM TO DRY MALT WITH GEOTHERMAL WATER

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***Abstract***

*By arrangement in the cylindrical inner cavity of the heat exchanger, a core of porous material with specific heat c convenient mass, the heat transfer problem is solved by exchange, which greatly reduces the amount of geothermal hot water necessary heat exchange, leading to increasing the thermal efficiency of drying malt plant with geothermal water.*

**Key words:** Geothermal water, heat exchanger porous medium, drying malt.

## INTRODUCTION

Industrial processes is an interesting target for the use of geothermal water.

Beach water temperatures below 423 K is considered geothermal used in basic processes such as preheating, washing, peeling, evaporation and distillation, sterilization and drying, etc.

Given the fact that the energy required pre-drying and drying process one tone of malt using the geothermal water heating is 3000 MJ, geothermal water temperature is 365 K, the temperature required for pre-drying Air Malta is in the range of 297 ÷ 318 K temperature of air required for drying malt 353 K and the temperature required pre-drying (withering) Malt humidity varies depending on such:

43÷34% moisture →296÷298 K

34÷24% moisture →299÷303 K

24÷12% moisture →313÷323 K,

By malt drying plant which used geothermal water, is recommended to use a heat exchanger with porous medium.

The porous core heat exchanger, heat transfer is achieved indirectly through a surface exchange (intermediate heat exchanger wall between the fluid and the environment). (Iancu C, 2011)

To maximize the heat transfer medium in heat exchangers of steel pipe or aluminum shot is necessary to increase the transport section and the hydraulic pressure and water volume reduction facility. These goals can be achieved by using cores of porous materials with appropriate $\lambda$ and c optimally placed inside the heat exchanger tubes. (Denis, 2008)

For drying malt plant uses geothermal water heat exchanger core of coke shown in Figure 1.

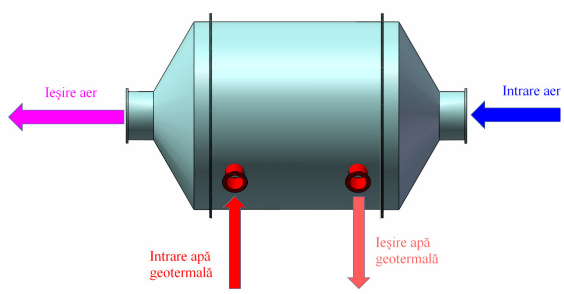


Figure 1. Heat exchanger with porous medium

This type of exchanger shown in Figure 2 consists of an insulated jacket to the outside, two baffles that are designed to swirl valve geothermal water pipes 3 and 4 foam core made of coke pore size of 0.1 ÷ 0.5 mm.

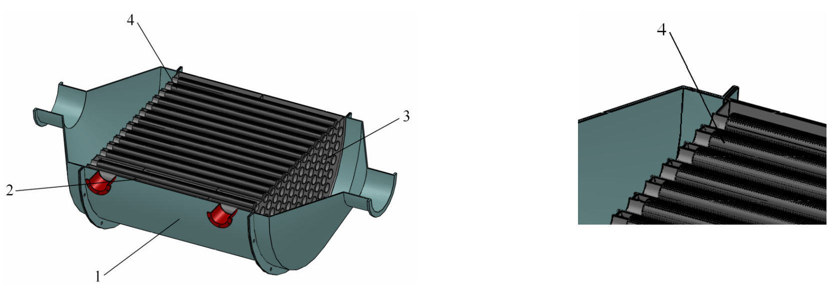


Figure 2. Section through the heat exchanger with porous medium

**MATERIAL AND METHOD**

Heat exchange surface area for porous media (SSP) with porosity size between 0.1 and 1 mm $M^2/M^3$ is 8000 while for plate heat exchangers with 4 mm distance between them (for air-liquid heat exchange) SSP is 630 M2/M3 porous medium, which provides a much smaller volume of the exchanger. (Iancu C, 2011)

Inlet and outlet temperature of air and water for geothermal exchanger is shown in Figure 3.

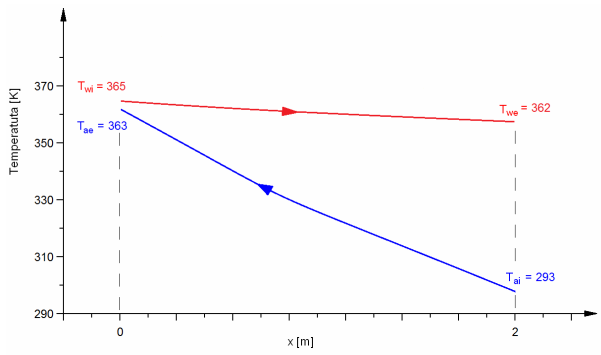


Figure.3. Inlet and outlet temperatures of air and water exchanger for geothermal

Use heat exchangers parallel beam pipes filled with coke. (Comsol 2008)

Required heat exchange surface is determined by the relationship:

$$S_w = \frac{Q_t}{\alpha_w \cdot \Delta T}\left[m^2\right], \qquad S_a = \frac{Q_t}{\alpha_a \cdot \Delta T}\left[m^2\right], \qquad S = \frac{Q_t}{k \cdot \Delta T}\left[m^2\right],$$

$$\Delta T = \frac{\Delta T_1 - \Delta T_2}{\Delta T_1 / \Delta T_2}\left[K\right], \qquad \Delta T_1 = T_{wi} - T_{ae}\left[K\right], \qquad \Delta T_2 = T_{we} - T_{ai}\left[K\right]$$

Air mass flow will be:

$\dot{m} = \dfrac{n \cdot Q_t}{c_p \cdot T_{ai} - T_{ae}}\left[Kg/s\right]$, Geothermal water mass flow will be:

$$\dot{m} = \frac{n \cdot Q_t}{c_p \cdot T_{wi} - T_{we}}\left[Kg/s\right]$$

For air, the relationship for calculating the convective heat transfer coefficient $\alpha_a$ is: (Comsol 2008)

$$\alpha_a = 0{,}024 \cdot \frac{\lambda_{CO2}}{d_i} \cdot \mathrm{Re}^{0.8} \cdot \mathrm{Pr}^{0{,}37} \quad \left[W/m^2K\right]$$

For hot water, the relationship for calculating the convective heat transfer coefficient $\alpha_w$ is:

$$\alpha_w = 1{,}72 \cdot \frac{\lambda_{ac}}{d_e} \cdot \left(d_{ech}\right)^{0{,}6} \cdot R_e^{0{,}6} \cdot P_r^{0{,}33} \quad \left[W/m^2K\right] \text{ (Comsol 2008)}$$

In these relationships, the similarity criterion Re is Reynolds and Prandtl Pr is the criterion of similarity.

At the macroscopic level is limited to solving Navier-Stokes equations by taking account of the border. Navier-Stokes's equations are a set of equations, written in the form, differential or integral, noting relations between fundamental quantities.

$$\rho C_p\left(\frac{\partial T}{\partial t}+(u\cdot\nabla)T\right)=-(\nabla\cdot q)+\frac{\tau}{S}-\frac{T\partial p}{\rho\partial T}\bigg|_p\left(\frac{\partial p}{\partial t}+(u\cdot\nabla)+Q\right)$$

**RESULTS AND DISSCUSIONS**

Study techniques and computer analysis of the processes of heat transfer and flow, both aimed at using new methods and extension of methods already known and is the subject of widespread research. (Iancu C, 2011)

For analysis of porous filling the heat exchanger (temperature, heat flux, pressure drop and speed) Comsol Multiphysics to use program that allows a problem solving and post processing heat exchange.

For the porous medium, the analysis of heat flow variation highlights for each area of the section, the share of heat transfer by convection and conduction.

Value flow in Figure 4. A figure 5.şi Figure 6. total stream flow is not porous medium heat transmitted from the air.

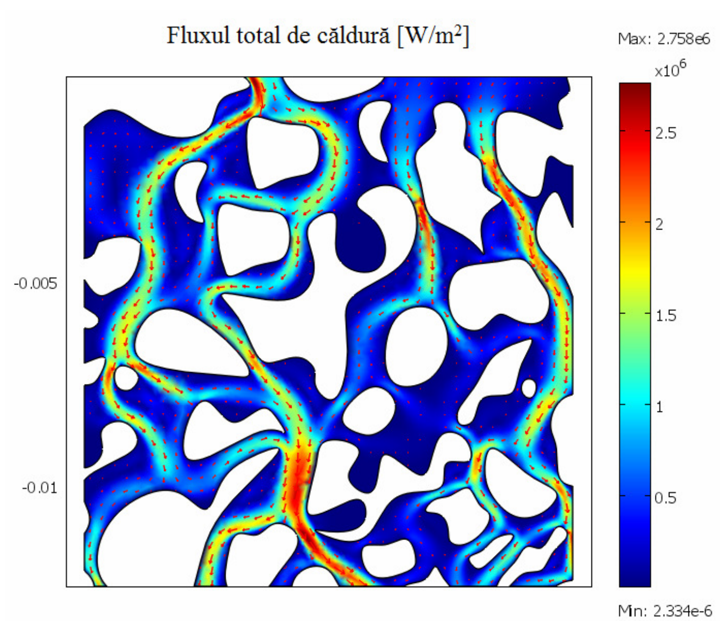


Figure. 4. Total flow of heat dispersion in porous medium

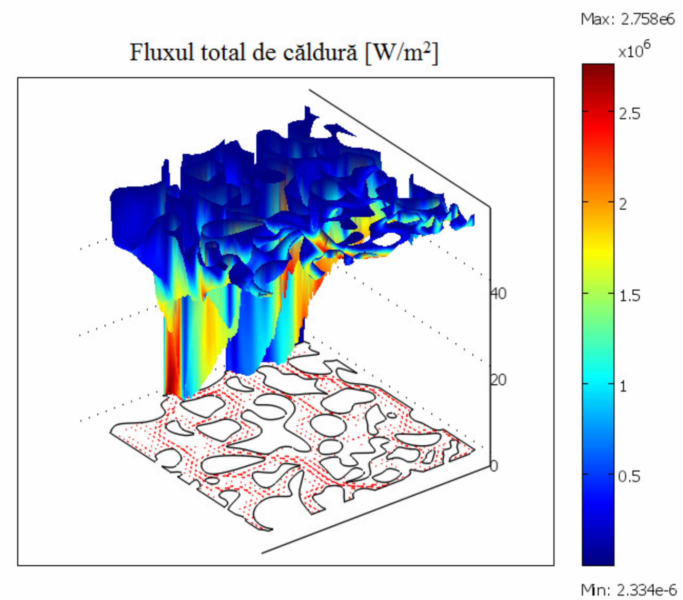

Figure. 5. 3D dispersion flow in porous medium heat total

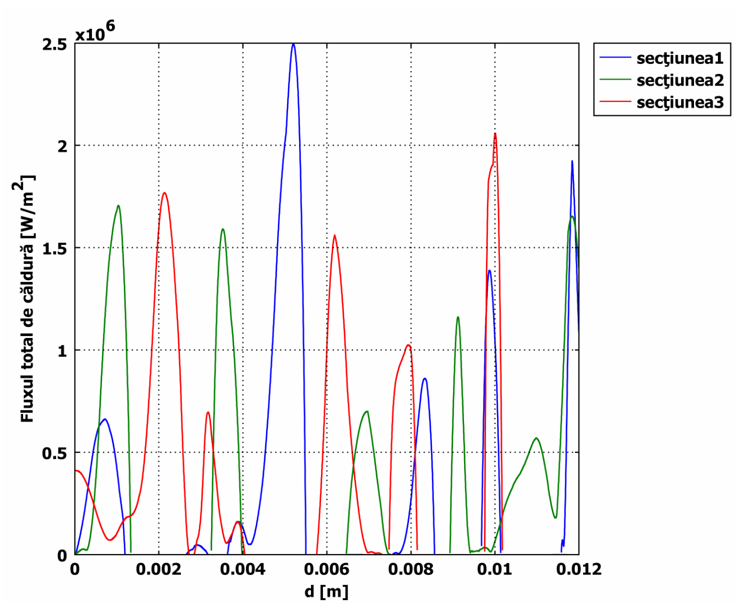

Figure 6. Diagram of variation of total heat flow in porous medium

It is noted that the total heat flow value is determined by the amount of air speed section. This is due to the weight of heat transfer by convection to the conduction.

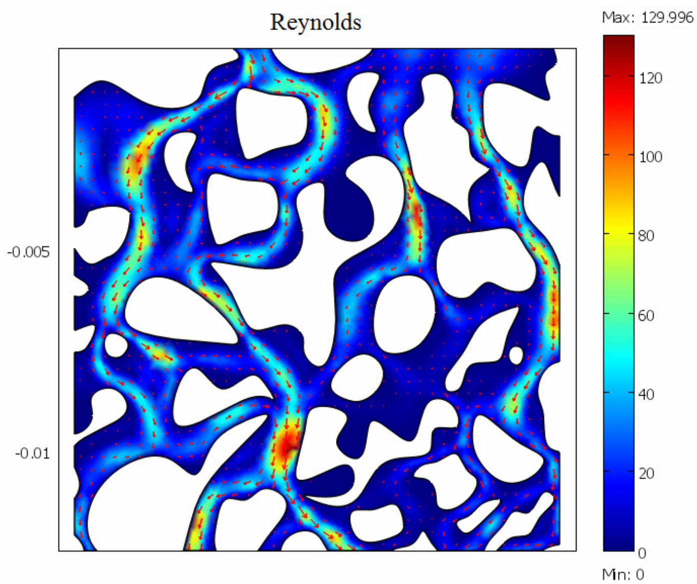

Figure 7. View Reynolds number in porous medium

It is noted that the porous medium, due to the randomness of the flow channel size and value their position, the Reynolds number is different on the same section.

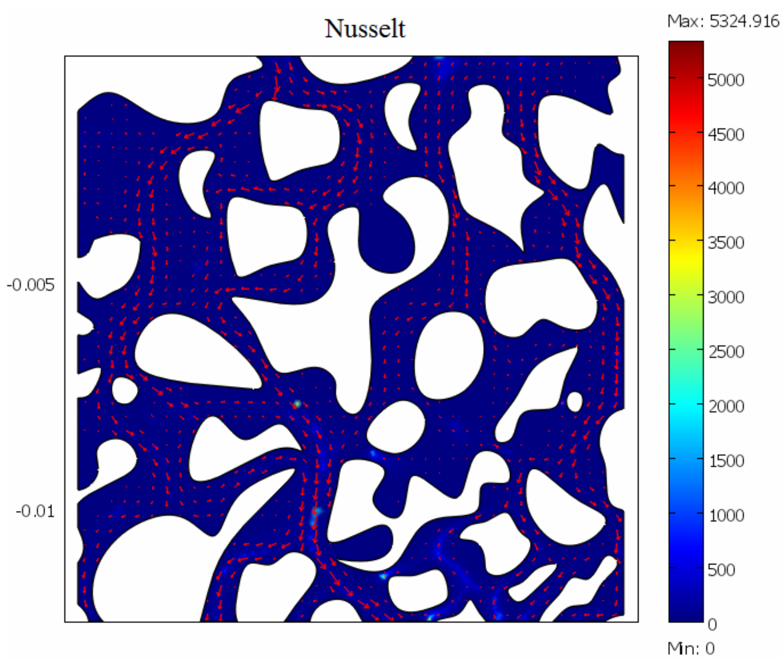

Figure 8. Nusselt number variation diagram of the porous medium

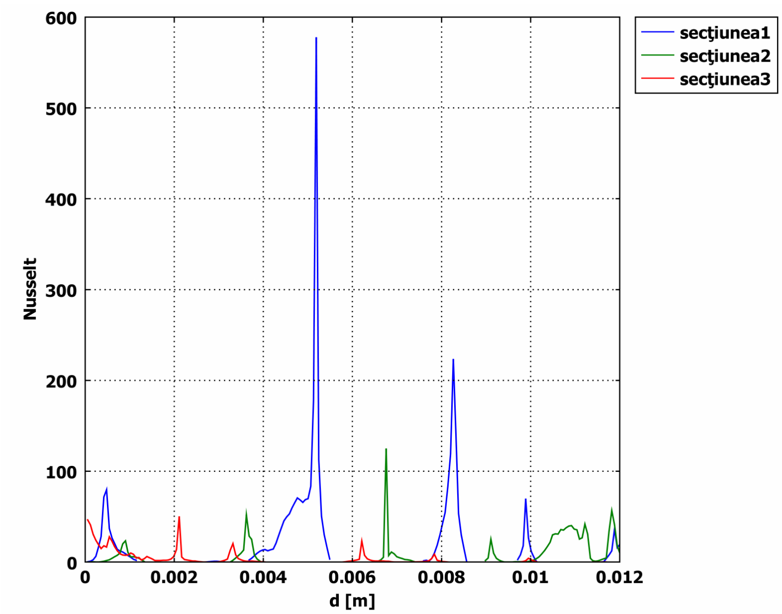

Figure 9. Nusselt number variation diagram of the porous medium

It is noted that due to large fluctuations in Nusselt number shows the speed values in a wide range (0 ÷ 600). (Iancu C, 2011)

**CONCLUSIONS**

Resource efficiency is a crucial issue given that resources are limited. Thus, the choice of heat exchanger is very important because the overall system efficiency is paramount and this can be done only benefit from the best technologies to minimize waste of resources. Optimizing resource consumption is a major issue in all areas of research for finding the optimal solution only in terms of technology we can achieve results in research. (Iancu C, 2011)

**REFERENCES**

1. Carmen Violeta Iancu, Vasile Bara, Gheorghe Sarca, Adrian Timar, Solutions of heat exchangers used in food industry, International Symposia, Risk Factors for Environment and Food Safety& Natural Resources and Sustainable Development, november 6-7, 2009, Analele universităţii din Oradea, Fascicula Ecotoxicologie, Zootehnie şi Tehnologii de Industrie Alimentară, pp 1242-1247, I.S.S.N. 1583 – 4301, Oradea, 2009;
2. Denis Marcotte, Philippe Pasquier: "Fast fluid and ground temperature computation for geothermal ground-loop heat exchanger systems" in Geothermicsnr.37, 2008 pg. 651–665, ELSEVIER;

3. Dionissios P. Margaris, Adrian-Gabriel Ghiaus: “Dried product quality improvement by air flow manipulation in tray dryers” in Journal of Food Engineering nr.75, 2006, pg. 542–550, ELSEVIER;
4. E. Kavak Akpinar: “Evaluation of convective heat transfer coefficient ofvarious crops in cyclone type dryer” in Energy Conversion and Management nr.46, 2005, pg. 2439–2454, ELSEVIER;
5. H.G. Wang, P.R.Senior, R.Mann, W.Q.Yang: “Online measurement of solids moisture in fluidised bed dryers” in Chemical Engineering Science nr. 64, 2009, pg. 2893- 2902, ELSEVIER;
6. Iancu Carmen, Utilaje □n Industria Alimentară, Editura Universităţii din Oradea, ISBN 978-606-10-0010-4, CNCSIS cod 149, Oradea 2010;
7. Iancu Carmen, Utilaje □n Industria Alimentară, lucrări practice de laborator, Editura Universităţii din Oradea, ISBN 978-973-759-939-1, CNCSIS cod 149, Oradea 2009;
8. Kailash N. Bhardwaj and S. C. Tiwari: “Geothermal energy resource utilization: Perspectives of the Uttarakhand Himalaya” in Current Science, vol. 95, nr. 7, 2008, pg. 846-850;
9. L. Sivill, P. Ahtila, M. Taimisto: “Thermodynamic simulation of dryer section heat recovery in paper machines” in Applied Thermal Engineering nr.25, 2005, pg. 1273–1292, ELSEVIER;
10. Setel Aurel, Iancu Carmen, ş.a., Utilizarea durabilă şi cu eficienţă maximă a energiei geotermale în zona Sacueni- Létavértes, Contract nr. HURO/0801/006, 2010 – 2011
11. Iancu C, Contribuţii privind proiectarea □i conducerea sistemelor care utilizează energia apelor geotermale din jude□ul Bihor. Teză de doctorat, 2010
12. Y. Babi, A. Dobbi, M. Saighi, B. Bouchekima: “Heating an agricultural greenhouse by using geothermal energy” in Revue des Energies Renouvelables CER’07 Oujda, 2007, pg.265-268;
13. Comsol Multiphysics – User Guide 2008;
14. A. Zavala-Río, C.M. Astorga-Zaragoza, O. Hernández-González: “Bounded positive control for double-pipe heat exchangers” in Control Engineering Practice nr.17, 2009, pg. 136-145, ELSEVIER;
15. Ahmed Maidi, Moussa Diaf, Jean-Pierre Corriou: “Boundary geometric control of a counter-current heat exchanger” in Journal of Process Control nr.19, 2009, pg. 297–313, ELSEVIER;
16. Alejandro H. González, Darci Odloak, Jacinto L. Marchetti: “Predictive control applied to heat-exchanger networks” in Chemical Engineering and Processing nr.45, 2006, pg. 661–671, ELSEVIER
17. Angel Vidal, Alfonso Bãnos: “Reset compensation for temperature control: Experimental application on heat exchangers” in Chemical Engineering Journal nr.159, 2010 pg. 170–181, ELSEVIER;
18. BurkhardSanner: “Geothermal energy opportunities for desert regions” in Global Conference on Renewable Energy Approaches for Desert Regions, Amman, Jordan 2006
19. C. Pantea, G.M. Rosca, C. A. Blaga, ”Power generation from low enthalpy geothermal resources” in Journal of sustenable energy, vol.1, nr.2 (2010);
20. Carmen Jover, Carlos F. Alastruey: “Multivariable control for an industrial rotary dryer”, in Food Control nr. 17 (2006) pg 653–659,ELSEVIER;