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Experimental analysis of heat transfer in porous medium with different material- Review

Ashwin M.Nandeshwar[1], Narendra N.Wadaskar[2]
[1]*Mtech Scholar, Guru Nanak Institute of Technology, Nagpur*
[2]*Assistant Professor, Guru Nanak Institute of Technology, Nagpur*

Abstract- **An experimental study to evaluate the dynamics of forced convection heat transfer in a thermally isolated column filled with porous medium has been carried out. The behaviour of two porous media with different grain sizes and specific surfaces has been observed. The experimental data have been compared with an analytical Solution for one-dimensional heat transport for local non thermal equilibrium condition. The interpretation of the experimental data shows that the heterogeneity of the porous medium affects heat transport dynamics, causing a channeling effect which has consequences on thermal dispersion phenomena and heat transfer between fluid and solid phases, limiting the capacity to store or dissipate heat in the porous medium.**

Index Terms- Heat Transfer, Porous Media, Nusselt Number.

1. INTRODUCTION

Heat transfer in porous media has recently become an important subject in mechanical engineering. This study presents experimental and numerical investigations of the effective thermal conductivity in porous medium. Effective heat transfer is essential in a variety of energy technologies in order to enable the maximum possible power density and power conversion efficiency needed for economic competitiveness and fuel conservation. The goal of enhanced heat transfer is to encourage or accommodate high heat fluxes. This results in reduction of heat exchanger size, which generally leads to less capital cost [1]. Another advantage is the reduction of temperature driving force, which reduces the entropy generation and increases the second law efficiency. In addition, the heat transfer enhancement enables heat exchangers to operate at smaller velocity, but still achieve the same or even higher heat transfer coefficient [2].Heat transfer enhancement technology has been widely applied to heat exchanger applications in refrigeration, automobile, process industries etc [3-8].In general, enhanced heat transfer surfaces can be used for three purposes: 1- to make heat exchangers more compact in order to reduce their overall volume, and possibly their cost,2- to reduce the pumping power required for a given heat transfer process, or 3- to increase the overall UA value of the heat exchanger. Heat transfer enhancement techniques can be divided into two groups: active and passive techniques. The active techniques require external power to facilitate the desired flow modification and the concomitant improvement in the rate of heat transfer. Augmentation of heat transfer by can be achieved by mechanical aids, surface vibration, etc.

2. RESEARCH METHODOLOGY TO BE EMPLOYED

A porous medium is a medium typically filled with structures such as granular solids, foams or fibres. Typically when fibres are used the porosity of the media is increased to over 90%. Such high porosity is mainly due to the complex surface chemistry and the irregular form of the fibres [3]. The medium usually undergoes some changes due to condensation of vapour, swelling in the fibres or other deformations but will be viewed as a rigid structure in this analysis. As can be seen in Figure 2.2, describing the fibres as uniform can be viewed as almost impossible as the exact shape and size distribution is highly irregular through the medium. This is a common problem in natural materials such as pulp. Since there rarely is any information regarding the consistency of properties in the material, various parameters are usually set as constant in a porous medium. As the material for the analysis is only observed in a macro scale, the medium can be seen as close to homogenous, thus regarding properties as constant is a valid assumption.

The thin outer-layer of the product consists of a breathable micro porous film. This film consists of solid man-made polymers such as polyethylene or polypropylene with additional inorganic fillers. One of the most common fillers is calcium carbonate ($CaCO3$) [2, 4]. As the polymers are man-made, their shape and position are more uniform than in the case of natural fibres and can more easily be chosen after desired properties [5].

Breathable micro porous films usually contain billions of small pores. Many of the micro pores are connected to each other creating channels through the film. The main function of the film is, in addition to keep the main layers of the product in place, to stop any leaking of liquid to occur. It is however of importance that vapour is able to transport through the film, in order to allow it to be breathable. Therefore the size of the pores needs to be much larger than the vapour molecules, but small enough to prevent any penetration of liquid [4].

To form the pores in the film, the plastic usually undergoes stress cracking by stretching the material mechanically. Due to the presence of fillers, the stretching can be done under normal ambient conditions and become more controlled [4]. Even though the polymers are more uniform than in natural fibres, the shape and size of the pores generally varies a lot as the channels created takes different paths through the layer. This will result in different distances for the moist air to travel in the medium and a uniform transport time cannot be guaranteed.

3. PROPOSED EXPERIMENTAL SETUP

REFERENCES

[1] Ganji, E.m.L.a.D.D., Heat transfer in porous media, University of Washington-Milwaukee, Noshirvani Technical University of Babol

[2] Havis, C.R., G.P. Peterson, and L.S. Fletcher, Predicting the thermal conductivity and temperature distribution in aligned fiber composites. Journal of thermophysics and heat transfer, 1989. 3(4): p. 416-422.

[3] Bakker, K., Using the finite element method to compute the influence of complex porosity and inclusion structures on the thermal and electrical conductivity. International Journal of Heat and Mass Transfer, 1997. 40(15): p. 3503-3511.

[4] Kou, J., et al., The effective thermal conductivity of porous media based on statistical self-similarity. Physics Letters, Section A: General, Atomic and Solid State Physics, 2009. 374(1): p. 62-65.

[5] Bouguerra, A., Prediction of effective thermal conductivity of moist wood concrete. Journal of Physics D: Applied Physics, 1999. 32(12): p. 1407-1414.

[6] Lv, Y.G., X.L. Huai, and W.W. Wang, Study on the effect of micro geometric structure on heat conduction in porous media subjected to pulse laser. Chemical Engineering Science, 2006. 61(17): p. 5717-5725.

[7] Hsu, C.T., A closure model for transient heat conduction in porous media. Journal of Heat Transfer, 1999. 121(3): p. 733-739. 29

[8] Aichlmayr, H.T. and F.A. Kulacki, A transient technique for measuring the effective thermal conductivity of saturated porous media with a constant boundary heat flux. Journal of Heat Transfer, 2006. 128(11): p. 1217-1220

[9] Zumbrunnen, D.A., R. Viskanta, and F.P. Incropera, Heat transfer through porous solids with complex internal geometries. International Journal of Heat and Mass Transfer, 1986. 29(2): p. 275-284.

[10] Prakouras, A.G., et al., Thermal conductivity of heterogeneous mixtures. International Journal of Heat and Mass Transfer, 1978. 21(8): p. 1157-1166.

[11] Takahashi, K., et al., Measurement of the thermal conductivity of nanodeposited material. International Journal of Thermophysics, 2009. 30(6): p. 1864-1874.

[12] Jannot, Y., A. Degiovanni, and G. Payet, Thermal conductivity measurement of insulating materials with a three layers device. International Journal of Heat and Mass Transfer, 2009. 52(5-6): p. 1105-1111.
[13] Bernasconi, A., et al., Dynamic technique for measurement of the thermal conductivity and the specific heat: Application to silica aerogels. Review of Scientific Instruments, 1990. 61(9): p. 2420-2426.
[14] Fourie, J.G. and J.P. Du Plessis, A two-equation model for heat conduction in porous media. Transport in Porous Media, 2003. 53(2): p. 163-174. 30
[15] Virto, L., et al., Heating of saturated porous media in practice: Several causes of local thermal non-equilibrium. International Journal of Heat and Mass Transfer, 2009. 52(23-24): p. 5412-5422.
[16] Vosteen, H.D. and R. Schellschmidt, Influence of temperature on thermal conductivity, thermal capacity and thermal diffusivity for different types of rock. Physics and Chemistry of the Earth, 2003. 28(9-11): p. 499-509.
[17] Akbari, A., M. Akbari, and R.J. Hill, Effective thermal conductivity of two-dimensional anisotropic two-phase media. International Journal of Heat and Mass Transfer, 2013. 63: p. 41-50.
[18] Gruescu, C., et al., Effective thermal conductivity of partially saturated porous rocks. International Journal of Solids and Structures, 2007. 44(3-4): p. 811-833.
[19] Usowicz, B., J. Lipiec, and J.B. Usowicz, Thermal conductivity in relation to porosity and hardness of terrestrial porous media. Planetary and Space Science, 2008. 56(3-4): p. 438-447.
[20] Nait-Ali, B., et al., Effect of humidity on the thermal conductivity of porous zirconia ceramics. Journal of the European Ceramic Society, 2013. 33(13-14): p. 2565-2571.