**Review on heat transfer performance in porous media**

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**Abstract**

 In the presented study, a review has been studied the history of heat transfer through porous materials. Four sides have been the focus of this review: materials, porosity, heat transfer and applications. The paper contains listed many references. It is provides an overview of previous research on knowledge sharing. Many papers reviewed here is relate to experimental works, including numerical, analytical for heat transfer systems. In addition of equipment’s design, heat transfer has a major role at applications for natural systems also.

**Keywords**: Porous media, Heat transfer, Forced convection

***1. Introduction***

 The purpose of a literature review is to carry the reader the information and ideas have been presented for a porous media, and what are the point of power and weak. The literature review give the researcher to be brought to this time limit related to the state of research in this region and make familiar with any different idea and viewpoints on the porous media.

***2. Previous studies on heat transfer through porous media***

***Hilal, K. H. et al. (2014)***, the authors conducted an experimental study of forced convection heat transfer for air in a rectangular porous duct. The pad is made of a (zig-zag) metallic wire mesh insert with 2 distinctive porosity values (ԑ) (0.97) and (0.99). Reynolds numbers (7,682; 12,497; and 17,323) and constant heat flux have been agreed upon for experiments. The findings indicate that as Reynolds and heat flux increased, the number of Nusselt grew, but when pad porosity increased, the number of Nusselt reduced. It has been discovered that [(Nonporous - Nuclear) / weight of pad] equals (84.34) and (40.49) for (ԑ= 0.99 and ԑ= 0.97) correspondingly, which has been found suitable for improving heat transfer between the pad weight placed into clear duct. Enhancing heat transfer through a porous rectangular duct while decreasing the original duct's weight and size [1]

***Brijendra, S. B. & S. K. Choudhary (2017),*** metal foam heat exchanger was used to demonstrate the thermal performance, which includes pressure drop and heat transfer by porous material. With regard to thermal applications, they create the production technology for lightweight materials. In both scholarly and industrial study, heat transfer through porous materials plays a significant role. The experimental data has been calculated for various performance parameters such as effectiveness, factor of friction, number of Reynolds and number of Nusselt. A compared for another porous medium of heat exchangers like (magnesium, nickel, copper and carbon) with aluminum foam in heat exchanger was made for heat transfer performance [2].

***Hilal, K. H. (2012),*** in this study, pressure drop as well as forced convection heat transfer over a packed duct that measures 12.50 by 12.50 by 100cm have been investigated. The pad was constructed using 48 units of the metallic wrapping coils (0.98 porosity). It has been discovered that when heat flux, Reynold number, and the surface of duct surfaces exposed to the rise of the heat flux, so do Nusselt numbers. In the case when heating the packed duct's bottom and top surfaces as well as its entire surface. The packed duct should have a Nusselt number that is (1.20, 1.19) times greater than empty ducts. The temperature of the side and top surfaces of the duct rises as the Reynolds number and heat flux fall. Temperature differences between the side and top surfaces increases while just the top surface is being heated and decreases to its lowest value when all duct surfaces are being heated. In addition, local heat transfer coefficient increases with rising Reynolds number, heat flux, and number of duct surfaces exposed to continuous heat flux, and decreases along the duct’s axial direction. As Reynolds number increases, the pressure loss across the packed duct increases. [3]

***Habeeb, L. J., Mashkour, &et al. (2012),*** In 3D laminar steady flows, an experimental analysis of heat transfer for both forced and free convection was provided. A glass cubic duct with the size 30x30x30 cm that is filled by saturated porous medium. The porous media with a homogeneous diameter (11.7mm) is utilized with plastic balls. The experimental work includes investigation of the influence of porous media on the forced convection at various heat flux values and for various (Re, PM) ranges of the Reynolds number (17.45 ≤𝑅𝑒, 𝑃𝑀≤22.13) for every heat flux. With regard to mean Nusselt number ranges (41.52 ≤ 𝑁𝑢 ≤ 82.85), the air enters from down and departs from the top in this experimentation. Findings demonstrate that average Nusselt number rises with rising Reynolds Number and reduces with rising heat flux. [4]

***Vu, J. (2017),*** in order to increase the precision of porous continuum models, this study has used computational modeling regarding porous medium for convective heat transfer. Convective heat transfer caused by forced flow via highly conductive porous blocks was predicted using CFD models. With regard to pore-level predictions, multiple domains were produced throughout a porosity range as well as pore diameter typical regarding graphitic foams using idealized geometric model for spherical-void-phase porous materials. The findings have been put to comparison with pore-level findings and show that it is necessary to modify solid phase conductivity of the porous material in order to take the solid structure complexity into account. [5]

***Tahseen A.T. (2007)*** many types of porous media are gravel and glass sphere respectively was used. The testes are carried out for two values of pressure gradient (Δp) along the channel. The pressure gradient is (1.7kpa) and (2.65kpa) with changing of the amount of heat flux for each pressure gradient. The dimensionless distribution of temperature were decreases as the increase of the dimensionless length of the channel where, the value of a gravel less than for a glass sphere. the local number of Nusselt is decrease withthe increase of Peclet number in both types and the value for glass sphere greater than that for gravel. The study shows that the number of Nusselt on the length of channel decreases with the increase of the dimensionless channel length both types of porous media for various values of the applied heat flux. This is because of the fluid bulk temperature is increase with the forward flow to the channel end. [6]

***Hussain, I. Y., &Yaseen, A. A. (2013),*** a forced convection heat transfer has been presented theoretically and experimentally from a flat plate which heated withset up in porous medium at a constant value regarding the heat flux. in experimental work, the impact of heat flux  and Reynolds number on local Nusselt number and temperature profile was investigated. The heat flux values were between 1,000 and 5,000W/m2, and the Reynolds numbers were (24,118; 44,545; 739,832; and 82,208). An experimental part is being simulated by an ANSYS Fluent program. The experimental element uses the numerical component, which includes initial values as well as the boundary conditions for both velocities and heat flux. In addition, the local temperature at the wall gradually rises with flow direction and falls with Reynolds number as heat flux increases. When moving away from a heated wall in a vertical direction, fluid temperature decreases in porous medium. The investigation came to the conclusion that there was an increase in local Nusselt number along with an increase in the Reynolds and heat flux. [7]

***Quintard, M. (2015)*** prepared a model of heat transfer in the porous medium demand todescription multiplescale for structures of porous medium. The more problem of heat transfer in porous medium has been indicated. For different behaviors, the different models were appearing on a whole scale, depending on interaction between different times and various lengths that describe this problem**.** Different models are examined and outlined of their relations. In addition, a more difficult heat transfer problems in porous medium were indicated, coupling with heat sources effect, boiling, radiation, mass diffusion, etc. [8]

***Rashidian, S., &Tavakoli, M. R. (2017)***, used a passive method in porous materials for the fluid flow for increasing the transfer of heat in heat exchangers. the thermal conductivity as well as effective thermal capacity regarding the flow are improved by the existence of porous medium along its path. Heat transfer through radiation will be accelerated by porous medium matrix, particularly for the flow related to two phases (gas-water). Material as well as its structure in the path of flow have been examined for both experimental tests and numerical simulations employing porous media with different percentages of porosity. The medium regarding porous in the stream's path has been proven to increase thermal conductivity and effective thermal capacity of the stream. In the case when using a porous solid state, the heat transfer velocity in systems using gas flow is increasing.[9]

***Barman, P. C. et al. (2016),*** various flow transport problems involve the phenomenon of heat transfer via a porous medium, which is significant. It has the benefit that the mass and energy equations relating to various flow and mass transport phenomena in the porous medium are all typically based upon the same medium regarding mass and energy conservation principles. It is evident that as Reynolds number as well as the porous layer thickness increased, so does the rate regarding the transfer of the heat in the flow direction. The wall thickness and temperature are constant for non-Newtonian fluid. In various Nanotechnology applications, it is found that heat transfer across a porous medium is helpful. There is a reduction into the difference of pressure due to increasing in parameter of porous medium which causes a reduction in fluid mass which reduces the fluid velocities. The method of finite difference is used to calculate the natural convection with unsteady state and mixed convection for vertical flat plate with isothermal condition with non-Newtonian fluid saturated porous media, which are simulate as a power law fluid. [10]

***Eleiwi, M. A. (2012)*** In saturated porous media for cross flow in cylinder the forced convection heat transfer was studied theoretically and experimentally. The equations of conservation of energy and momentum were derivationusing Darcy flow model. A finite difference method was used to solved two equations at constant cylinder surface temperature, with Peclet numbers ranging in (1<Pe<10). Experimental work collected of cylinder of cupper material of (13 mm dia.) which heated using an electrical source. This cylinder has been embedded in the glass spheres (12 mm dia.) which placed in wind tunnel of low velocity. The results detected the increasing in heat transfer with Peclet number increasing theoretically and the experimentally. [11]

***Siva M. M. R., Venkatesh,&et al. (2016),*** examined experimentally the transfer of the heat in the porous medium under forced convection for flow of water. at various porosity, area and position have been conducted with 36 sets of experiments for heat transfer. at the outlet and inlet cross sections, the bulk temperature as well as pressure are monitored. It is possible to acquire local Nusselt and pressure drop numbers. Steel balls utilized as a porous medium Finding how Nusselt number varies with area, porosity, and position is the primary goal of the experiment. When put to comparison with a clear flow case without porous materials, it was found that the maximum heat transfer increasing took place with the least amount of pressure drop when the core had a diameter of 55mm and a porosity of (0.44), which was 4.6 times greater. According to the calculation, this particular combination of porous insert design, area, and porosity had lowest ΔP/Nu value. [12]

***Pastore, N. et al. (2018),*** analyzed the subject through thermal transfer experiments and their interpretation on a laboratory scale. For a column which thermally isolated and filled with the porous medium an experimental study was studied at forced convective heat transfer. The porous medium behavior with multi sizes of grain and surfaces wasnoticed. For condition of 1-dimensional heat transport local non-thermal equilibrium phenomena**,** an analytical solution have been compared with experimental data. the experimental work's local non-thermal equilibrium demonstrates how the dynamics regarding heat transport are impacted by the porous media's non-homogeneity. Heat transfer has an impact on heat transfer and thermal removal between liquid and solid phases, which in turn limits the capacity regarding porous media for storing or dissipating heat. [13]

***Haji-Sheikh, A., &Vafai, K. (2008)*** the subject of this studied the transform the heat fluid passing through a duct with porous medium. A different cross sectional geometries in channels have been submitted **with temperature solutions derivation**. firstly, Graetz problem investigated for channels of parallel plate and tubes of circular sections**.** Brinkman’s model solution used for two ducts. based on weighted residuals method, the results compared another numerical previous study. The weighted residuals method used for flow as well as heat transfer in passages of elliptical shapes. At different aspect ratios of elliptical passages section, the fluid flowing fluid have the heat transfer computation.[14]

***3.conclusions:***

 The research presented by each researcher can be categorized as follows:

1. Studying the effect of the difference in pressure (Pressure drop) inside the duct on heat transfer coefficient through porous media.
2. Studying the effects of porous media and porosity on Prandtl number (Pr), Peclet number (Pe), Biot number (Bi) and Grashof number (Gr).
3. Studying porous media effect, permeability and porosityon Darcy number (Da).
4. Many researchers find an experimental relationship between Reynold Number (Re) and Nusselt Number (Nu).
5. Study and test others porous media of a similar metal type and similar dimensions but with different porosity.
6. Changing the dimensions regarding the duct effects on the heat transfer through porous media.

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**مراجعة أداء انتقال الحرارة في وسط مسامي**

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 **الخلاصة**

 **في هذه المراجعة، تم دراسة التدرج الزمني لانتقال الحرارة خلال المواد المسامية. وقد ركزت المراجعة على اربعة جوانب هي: المواد، المسامية، انتقال الحرارة وتطبيقاتها. تم استعراض البحوث السابقة ذات الشراكة المعرفية للموضوع. العديد من البحوث ترتبط بالجانب العملي، وتتضمن البحوث الرقمية والتحليلية لانظمة انتقال الحرارة. اضافة الى تصاميم العدة المستخدمة فان انتقال الحرارة لها الدور المهم في انظمة انتقال الحرارية طبيعيا.**