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In a Triangular Duct Filled with Porous Material, Convection Heat Transfer is Experimentally Investigated

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ABSTRACT

The current study conducts an experimental investigation of porous media. The packed duct is 1.5 m in length and has a diameter of 0.2 m. It is filled with porous meduim composed of glass bed of three different sizes (5 mm, 12.21 and 15 mm). (0.5,0.6, and 0.7) are the corresponding porosity values for the channel. This study investigates how changes in porosity and Reynolds number affect local Nusselt number and increased heat transfer coefficient. Using a porous construction, as opposed to an empty duct, increased the convection coefficient (hx) considerably by (84.2%, 86.2% and 88.18%) at porosity (0.5,0.6, and 0.7), respectively. The outcomes also showed that the local Nusselt number reduced as the air velocity rose and the flow's axial increased. As the air velocity grew. As a result, Re number rises with the diameter of glass spheres while the drag coefficient falls. When the findings of the present study were compared to those of earlier studies, they were satisfactory. The Nusselt number and the Reynolds number have established correlational links.

1. Introduction

The porous medium has a wide range of applications and industries. Geology, industry, and nuclear power have all made use of it. Devices that are essential in energy saving and heat transfer include high-power electrical file structures and granular or porous insulators [1,2]. Furthermore, employed in building, porous media is also used to insulate nuclear reactors, keep things dry, and store solar energy [3-6]. This equation [4-8] states that fluid velocity is inversely proportional to fluid viscosity in a duct filled with highly permeable material. It was essential to determine how well the porous channel could transmit heat given how many different technology applications employ porous materials. Both conduction and convection heat transfer utilize porous medium [9-13]. The aim of this article experimental examination heat transfers by convection in a triangle duct with -without a porous material. In order to determine their effects on the temperature profile, heat transfer coefficient, Nusselt number, at range the Reynolds number range (3000–12000) for three porosity values (0.5,0.6 and 0.7).

2. The Experimental Rig

The diagrammatic representation of the experimental setup in Figure 1 . The channel is made of a galvanized sheet with a thickness of

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0.15 m and 2 m length, a hydraulic diameter of 0.2 m, and equilateral sides of 0.15 m. (2 mm). Glass spheres with three different diameters—12.21 mm, 15 mm, and 5 mm—were utilised in this research to analyse convective heat transfer and fill the test section. A glass sphere's average diameter was first determined using an electronic digital vernier calliper with the ball clamped within. As illustrated in Figure 2.

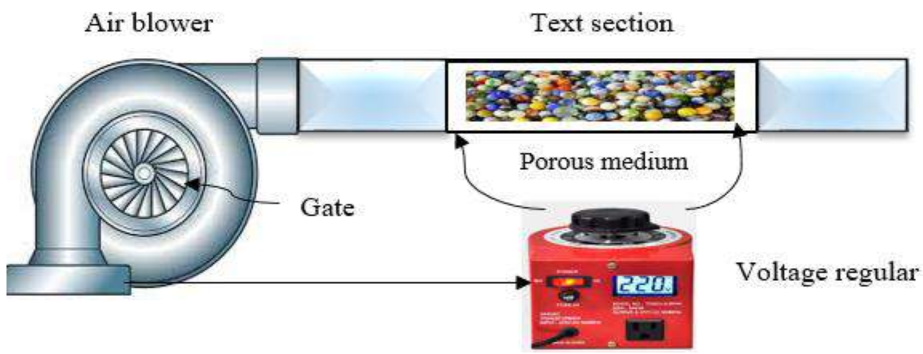
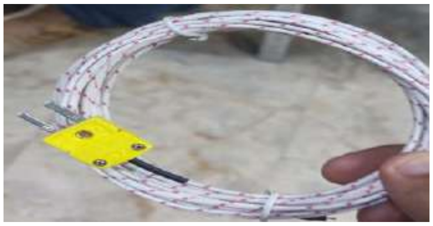


Figure 1 shows a schematic of the testing equipment

Figure 2: Porous media with farina.

In the device, the temperature is measured using thermocouple Type-K (chrome-alumel) wires, as shown in Figure 3. On the surface of the duct, 18 sensors were put, the duct was split into six parts, and every ports, were inserted in the face of the channel. Moreover, two thermo were positioned at the start and finish of the test portion to measure the temperature of the air. 20 sensors are therefore employed in total, as seen in Figure 3. The temperature of the system was also recorded using an Arduino mega system and an Uno cart.



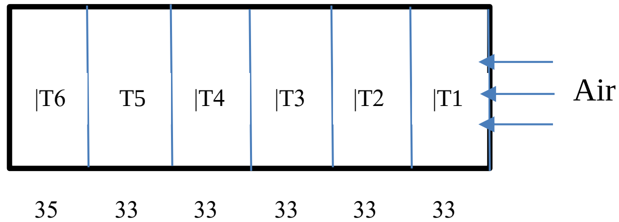


Figure 3: Thermocouple and locations.

3. Results and Discussion

The temperature distribution throughout the duct was measured with continuous heat flow and Reynolds values ranging from 3000 to 12000. Six average sites installed on the inside surface of the duct are shown in direct readings of the axial distance temperature distribution in Figures 4 to 6. Figure 5 shows reading of the temperature profile for a duct with a porosity of (0.6), and Figure 7 shows a direct reading of the temperature curve for a channel with a porosity of (0.5) in various Reynolds numbers. When the axial location and air velocity increase while maintaining the same heat flux, the local wall temperature (Tx-Ti) rises continuously in all ducts. Consequently, a surface duct with porosity (0.5) has a higher temperature than a duct with porosity (0.6), which has a higher temperature than an empty duct.

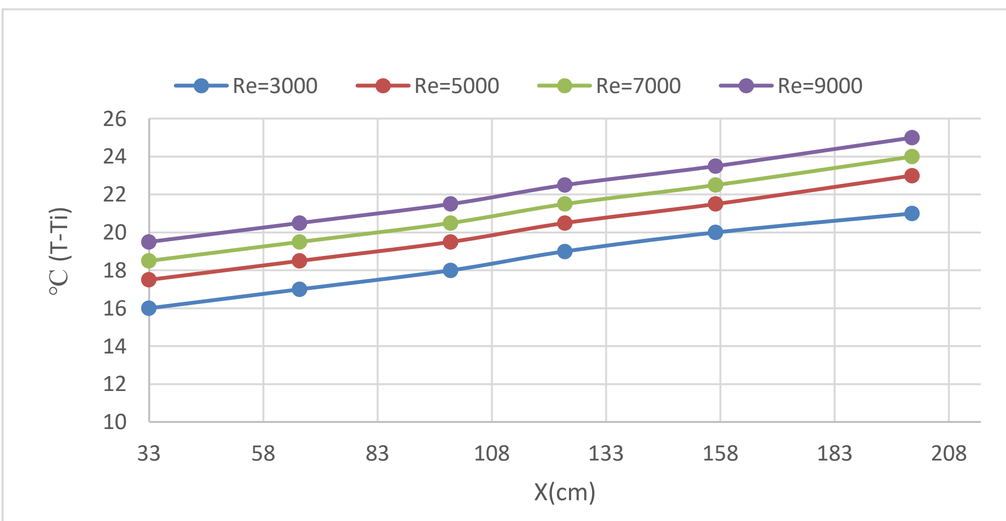


Figure 4 illustrates the local wall temperature at various Reynolds numbers.

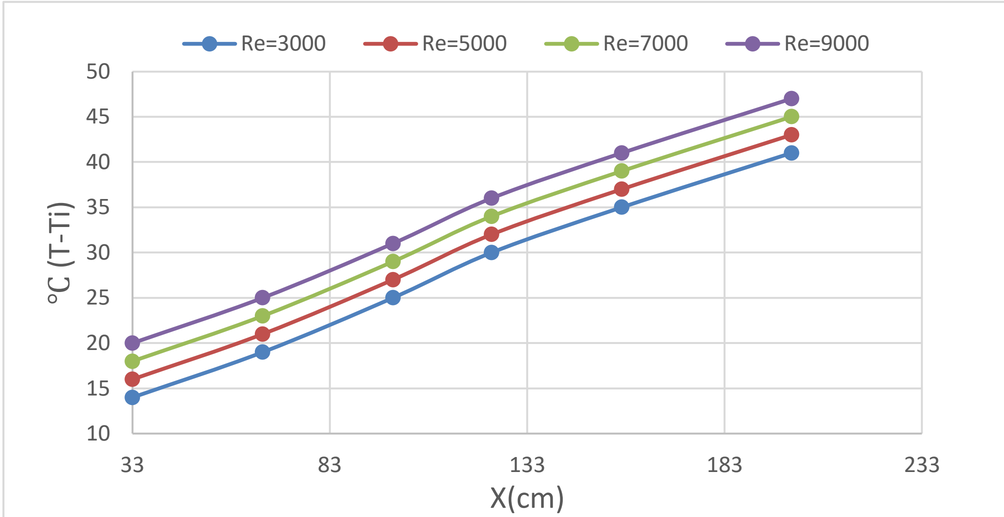


Figure 5 shows the duct's local wall temperature for various Reynolds numbers at (=0.6).

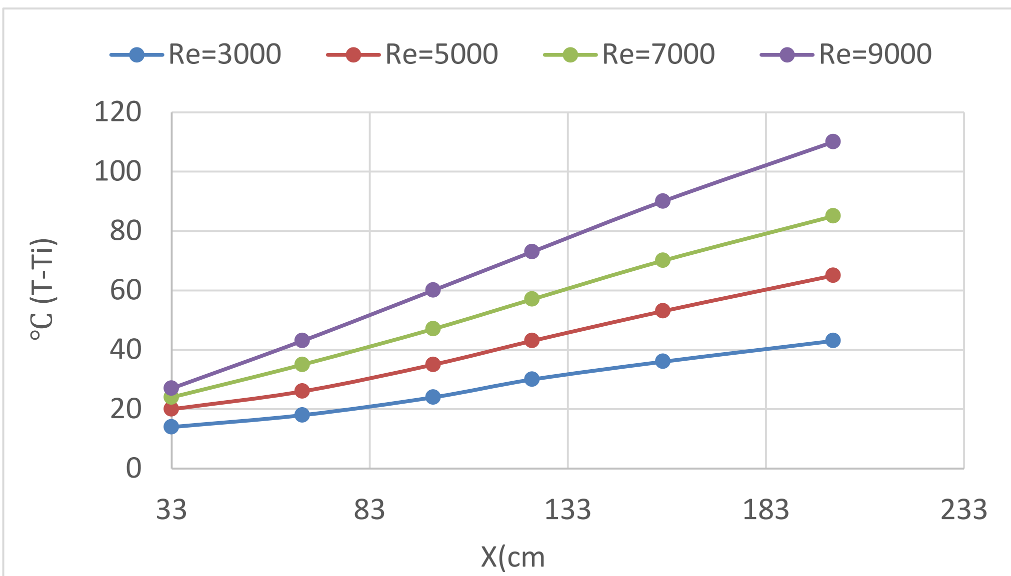


Figure 6 shows the local wall temperature for ducts at various Reynolds numbers when the pressure is (=0.5).

The changing porosity on the temperature along the duct at (0.5,0.6, and 0.7), is seen in Figures (7), (8), and (9). Every drawing has a fixed Reynold number (3000,7000, and 12000, respectively). In the empty duct, it is initially seen that the local wall temperature is lower. Then, it progressively increases when a porous media with a glass diameter of 12 mm is poured into the duct, and it eventually rises when a diameter of 5 mm is poured into the duct. The reason is that a porous substance will create air resistance in the duct when it is filled. The air resistance increases as the porosity diminishes. As a result, the duct's surface temperature rises.

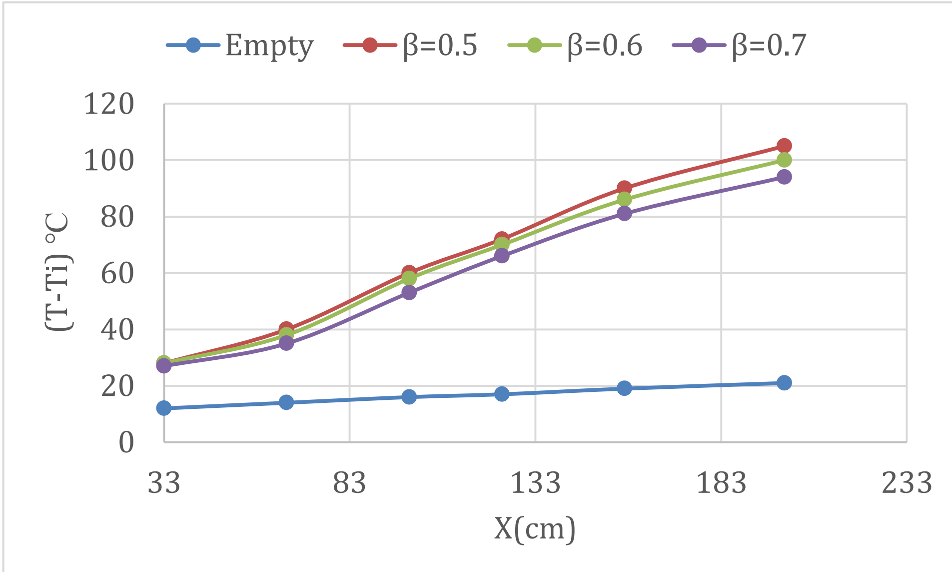


Figure 7 shows how the distribution of temperature along the duct at (Re = 3000)

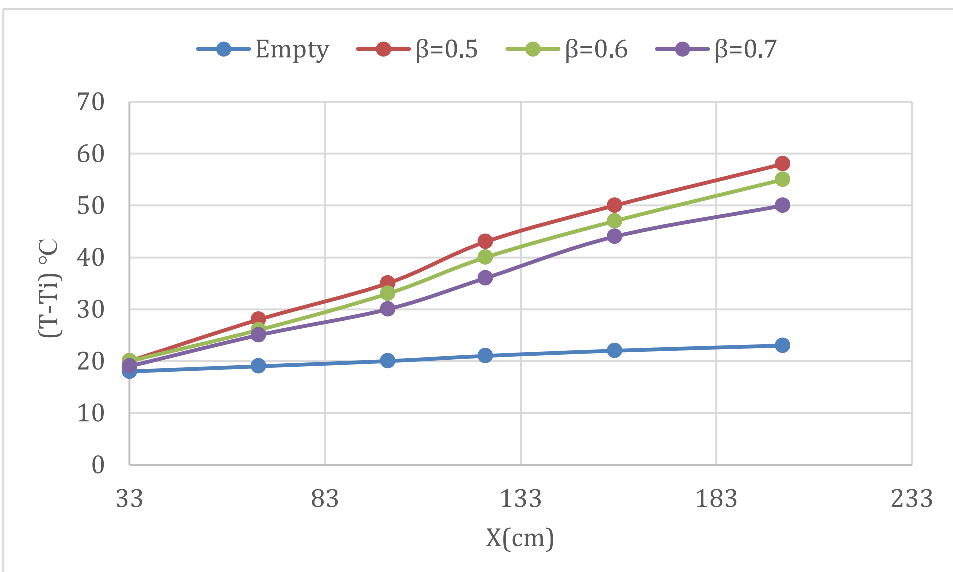


Figure 8 shows the impact porosity on the duct's temperature distribution at (Re=7000).

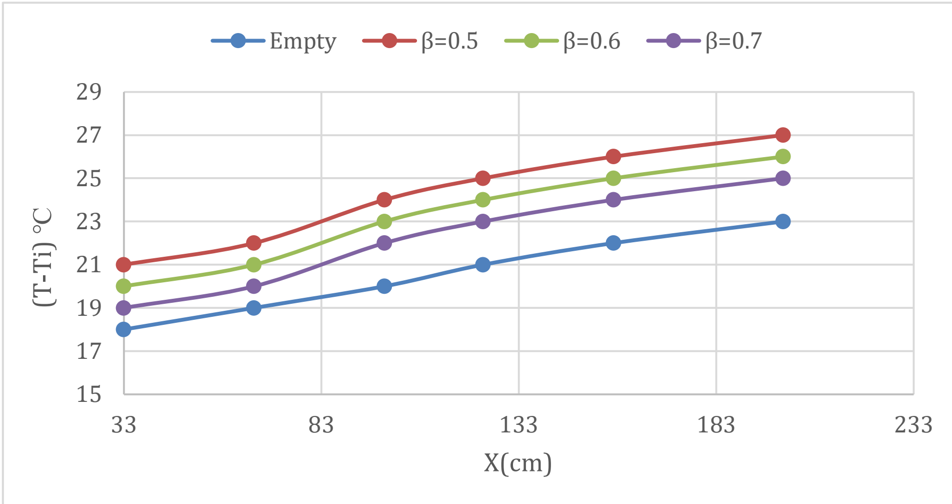


Figure 9 shows how the distribution of temperature along the duct at (Re=12000)

Figures 10 to 12 show the (hx) values for three channels-empty, at approximately 0.6, and at about 0.5-over a range of Reynolds numbers and constant heat fluxes. In the channel, it is highest at (β= 0.5). It gradually becomes down starting at (β= 0.6), and it drops significantly in the empty channel. When the channel proceeds in the direction of the fluid flow the coefficient of local heat transfer increased as Reynolds number increased.

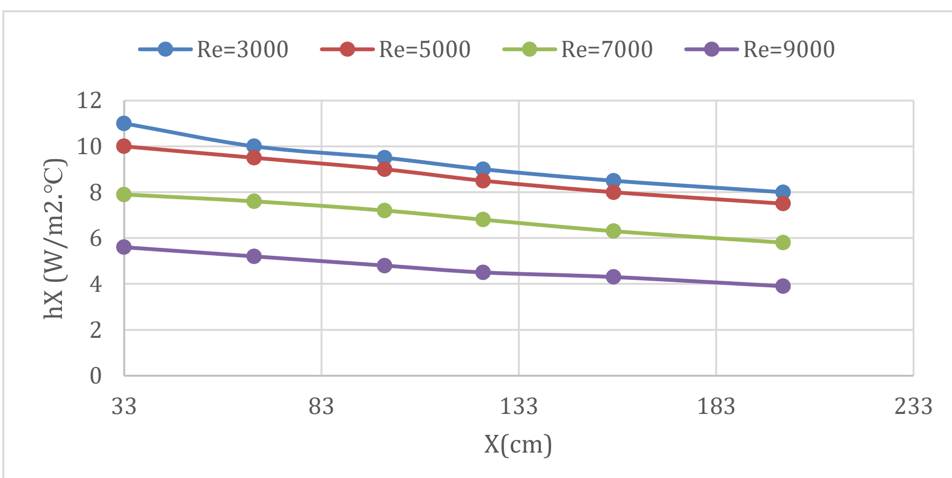


Figure 10: hx through the empty duct as a function of air velocity

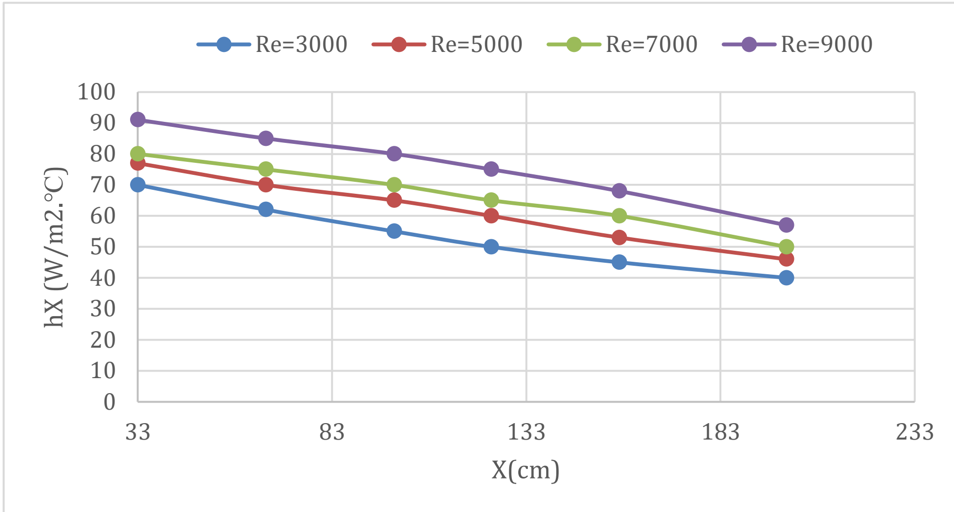


Figure 11 shows the air velocity with hx for a duct at (=0.6).

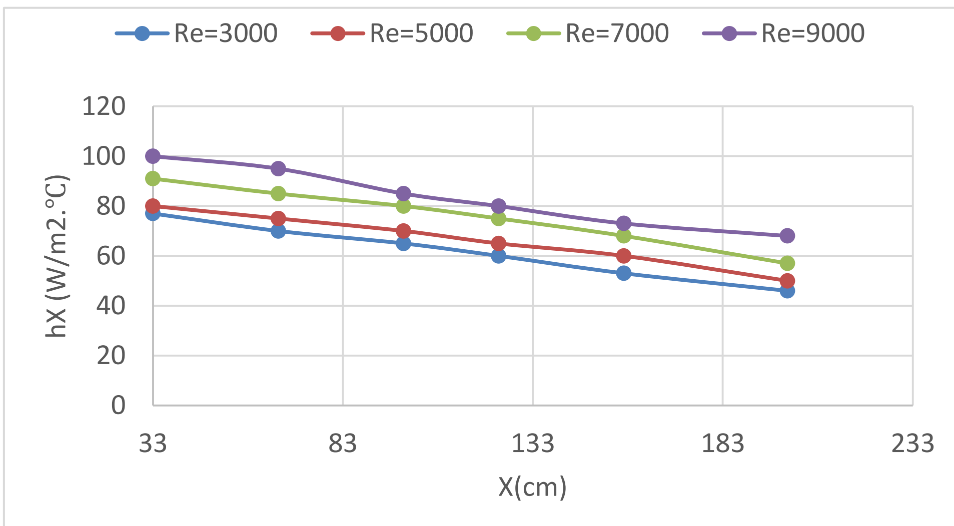


Figure 12: Effect of the air velocity on the (hx) for duct at (Ɛ=0.5)

When the Reynolds number increases, the average Nusselt number increases along with a steady heat flow. The average Nusselt number is high because there is little temperature variation between the wall duct temperature and the temperature of the air bulk. Figure 13 illustrates this relationship. The average Nusselt number and Re number are correlated and experimentally related by the formula **Nu = C Re^{m}** in the current study.

$Nu = 0.234\ Re^{0.5156}\ for\ (Ɛ = 0.5)$, Re (3000 – 12000) (1)
$Nu = 0.1527\ Re^{0.529} for\ (Ɛ = 0.6)$, Re (3000 – 12000) (2)
$Nu = 0.056 Re^{0.5234}\ for\ (Ɛ = 0.7)$, Re (3000 – 12000) (3)

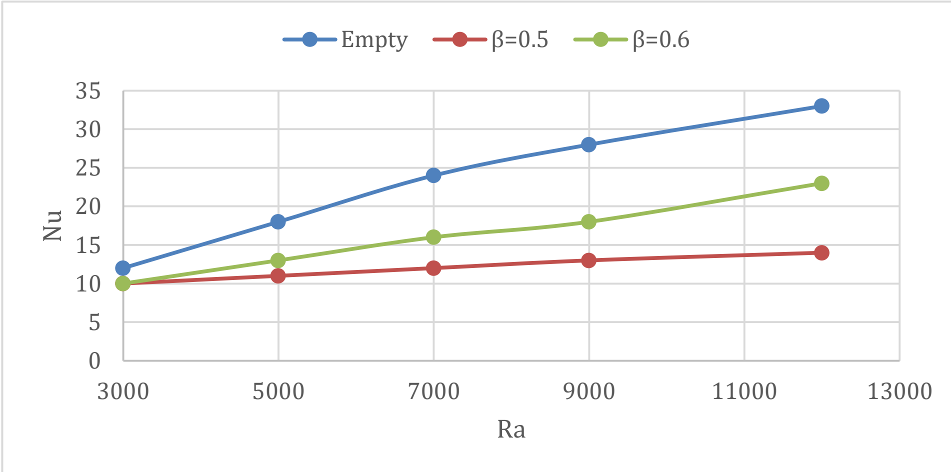


Figure 13: Average Nusselt number at duct with Ra

4. Conclusions

1. When the air velocity increases while the heat flow remains constant, the local temperature along the channel decreases.
2. The local tempe. for the channel is more at (β= 0.5) than it is at (β= 0.6), which is greater than it is without porosity.
3. Nevertheless, when (Re > 10000), it decreases in the duct that is filled with the porous media.
4. As compared to the empty duct, the average heat transfer coefficient increased by (84.2%, 86.2% and 88.18%) at porosity (0.5,0.6, and 0.7).
5. 5-This is a result of the viscous and turbulent forces that create resistance in glass bed.
6. The Nusselt number and the Reynolds number were shown to be correlated and experimentally related in the current investigation.

5. Referance

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