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Experimental Investigation of Flow Characteristics through Circular Tube with Porous Medium

[1]Sunil , [2]P V Ramana
[1]Asst. Professor St.Martin's Engineering college Secunderabad, Telangana, India
[2]Associate Professor, Dept. of Mechanical Engg. CVR COE, Hyd, TG, India

Abstract : *In this experiment flow characteristics of air is investigated when air flows through the circular tube having porous medium. In this experiment porous medium is made by G I material and study is done on G I material. The flow characteristics like frictional factor, Nusselts number and Reynolds number are investigated for varying the porosity and pitch of the porous medium. The results of circular tube with porous medium are compared with circular tube without porous medium.*

I. Introduction

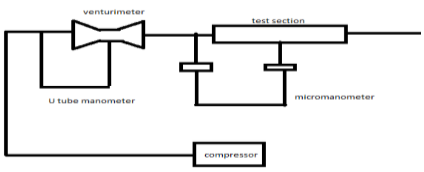
Fluid flow porous medium common in nature and many engineering filed. Every day flow phenomenon includes transport of water in living plants, trees, fertilizers and wastes in soil. In engineering filed fluid dynamics in various filed and hydraulic system like oil recovery. In many cases the porous structure of the medium and the related fluid flow are complex. The study of gas flow through the porous medium is help to improve the removing of dissolved substance in ground water by air injection. It is also used in stripping where the unwanted components are removed from a liquid stream by a vapor stream, air injection in applied to create the vapor streams which are favorable for unwanted components.

In urban area water management the aeration of filter for water treatment is traditional used and gradually gaining popularity also in waste water treatment. But also other filed Colum as in chemical engineering, migration and escape of gas in permeable sediments in marine sciences and air pressure.

In the engineering equipment's where the fluid is the working medium like hydraulic machines, fluid flow through the pipes , flow through the channel anpower plants in all this process the effect frictional factor, flow changes from laminar to turbulent (Reynolds number) and pressure drop are meager problem. The fluid flows through the radiator and the heat transfer equipment involves the porous medium to improve their efficiency.

In this experiment flow characteristics investigated done on the porous medium made by G I sheet and pressure drop , frictional factor , Reynolds number and Nusselt number effect is studied and the output result is compared with circular tube without porous medium

II. Methodology



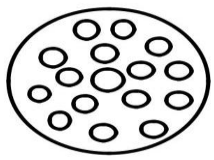
A schematic arrangement of the experimental set up used in the measurement of pressure distribution and temperature is shown in Fig. Air from a compressor passes in the test section through a venture meter, where the volume flow rate is measured. The Reynolds number based on the duct diameter was varied from 4225 to 11664. Compressor delivers the air; air enters into the test section through the valve which controls the flow of air through the test section. Using venturi meter and simple U-tube manometer the flow rate of air is maintained to required value, when air flows through the test section there is friction between air and surfaces of the circular duct. Due to this pressure drop takes place. This pressure drop across the test section is measured by using Micro-Differential manometer. Same process is followed to obtain the friction factor for different configurations of the porous medium which are placed in the circular duct. The measurement of pressure drop was done at the atmospheric temperature condition (i.e. tests without heating) and the friction factor was finding in terms of pressure drop across the test section of circular tube and the mass velocity of air.

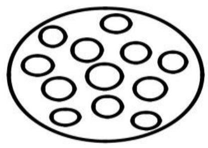
Geometry and Computational Details:

Circular shaped 90 degree angled porous medium are placed into mainstream flow direction on the circular duct to study the flow characteristics. The circular duct are denoted as p, d, L, D and ε are given below

Pitch (p): it is the distance between the two identical porous medium on the spaceman.
Diameter (d): it is the diameter of the porous medium used.
Porosity (ε): it is the porosity of porous medium used.
Diameter (D): it is the diameter of the circular duct.
Length of the circular duct (L): it is the length of the test section.

In this project we are using G I material with voids is porous medium. GI material has thickness 0.2mm, having the voids 1.63mm, 2.03mm.the two materials shown below





Voids=1.63mm Voids=2.03mm

Center void=2.05mm Center void=2.05mm

Outer diameter=24.5mm

Porosity (ε) =6.73% Porosity (ε) =8.28%

Data reduction:
1.FLOW RATE THROUGH VENTURE–METER

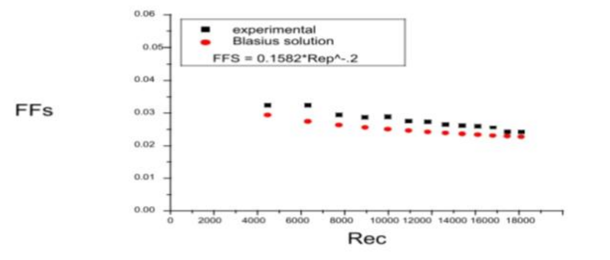
$$Q=C_D \frac{\quad}{\sqrt{A1^2-A2^2}} \sqrt{2gHa}$$

A1= Area of pipe
A2= Area of throat
Cd = Co-efficient of discharge
2. MASS flow rate
M= ρA QTH
3. The Reynolds number based on the channel hydraulic diameter
R=ρU(D/μ)
4. Friction factor
Blass's. *FFS* (0.1582 * Re^ 0.2)

III. Results And Discussions

Results of smooth tube:

Fig shows that the change of friction factor with Reynolds number for the smooth circular tube. FFs are the smooth tube friction factor obtained from experiment. These values are compared with the theoretical friction factor obtained from the Blasius equation for the smooth channels i.e. FFs=0.1582*Rep^-2 for the validation of the experimental results. From this graph the experimental results for friction factor in smooth circular tube reasonably agree well within ±5% values estimated from correlation proposed by Blasius**.**



:Results of smooth channelvalidation

Effect of friction factor on Reynolds number:

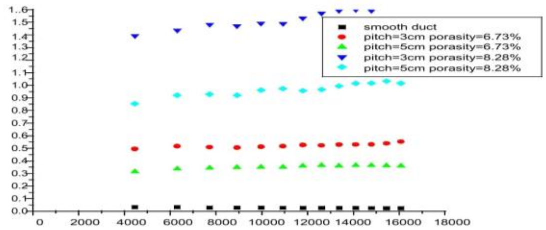


Fig shows the friction factor for different Reynolds number. The friction factor is very high when the porous medium is placed in the circular channel and without porous medium in the channel friction factor is low as above shown. As the Reynolds number increases the friction factor also increases in the circular channel with porous medium and decreases in circular channel without porous medium. Because the porous medium creates the high obstruct to the flow of fluid inside the circular channel. If we observe above figure 4.2 as the porosity increases the friction factor increases i.e. ε=8.28%. By increasing the pitch friction factor is decreases i.e. p=5cm and decreasing the pitch the friction factor is increases i.e. p=3cm.

Effect of friction factor on porosity:

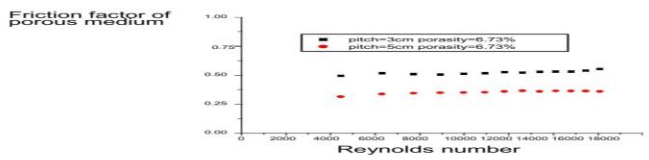


Fig 4.1.3.1: friction factor withe porosity=6.73%

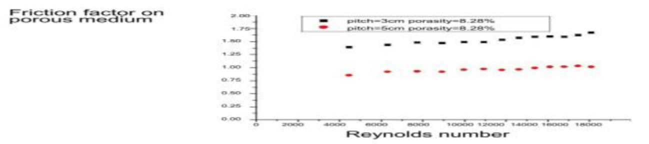
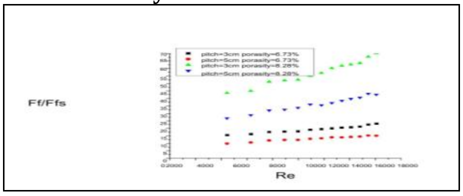


Fig 4.1.3.2: friction factor withe porosity=8.28%

Fig 4.1.3.1 and 4.1.3.2 showed the effect of friction factor on the porosity. As the porosity increase the friction factor also increases i.e. ε=8.28% and friction factor decreases as the porosity decreases ε=6.73%. As the Reynolds number increases the friction factor also increases. There is also observed that as pitch increases p=5cm friction factor decreases and as pitch decreases p=3cm friction factor increases.

Effect of Reynolds number on Friction Factor ratios (FFp/FFs):



By comparing the plots of variation Ff/Ffs with Reynolds number, Ff/Ffs ratio initially it will either increase and then it will increase for a particular Reynolds number and again it start to decrease. You can see that in case of without porous medium Ff/Ffs ratio initially increases and from Reynolds number 8920.31 it starts to decrease as Reynolds number increases. But in the case of without porous medium friction factor decreases as the Reynolds number increases. If we compare to the smooth channel the friction factor very low and in the channel with porous medium is very high.

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