Analysis of flow and heat transfer in cylinders

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ABSTRACT

The hydrodynamics and warm practices of fluid flow in pivotally moving small scale concentric chambers are examined scientifically. Impacts of Knudsen number, speed and range of the chambers on the microchannel hydrodynamics and warm practices are explored. It is discovered that as Kn builds the slip in the hydrodynamic and warm limit condition increments. The slip and the seize the internal surface are a lot bigger than that of the external one. At the point when the external chamber speed approaches the inward chamber one, the slip speed evaporates. Likewise, the impact of the variety of U1 on the temperature hop for adiabatic external surface is insignificant.

Keywords: Axially moving Micro-cylinder Microchannel Thermal and hydrodynamic Slip velocity Temperature jump

1. Introduction

Liquid flow in microchannels has risen as a significant region of research. This has been inspired by their different applications, for example, therapeutic and biomedical use, PC chips, and concoction divisions. The coming of small scale electro-mechanical frameworks (MEMS) has opened up another examination zone where non-continuum conduct is significant. MEMS are one of the significant advances of mechanical advances in the previous decades. MEMS allude to gadgets which have a trademark length of under 1 mm yet more prominent than 1 μm, which join electrical and mechanical parts and which are manufactured utilizing coordinated circuit creation innovations. Micronsize mechanical and biochemical gadgets are winding up progressively predominant both in business applications and in scientific inquire about. Microchannels are the essential piece of microfluidic frameworks. Notwithstanding interfacing various gadgets, microchannels are additionally used as biochemical response chambers, in physical molecule partition, in inkjet print heads, in infrared locators, in diode lasers, in little gas chromatographs, or as warmth exchangers for cooling PC chips. Understanding the flow attributes of smaller scale channel flows is significant in deciding weight circulation, heat move, and transport properties of the flow. The trademark measurement related with the expression "microchannels" is equivocal. Ostensibly, microchannels might be defined as channels whose trademark measurements are from one micron to one millimeter. Commonplace applications may include trademark measurements in the scope of roughly 10 to 200 μm. For the most part, over one millimeter the flow shows conduct which is equivalent to continuum flows. The

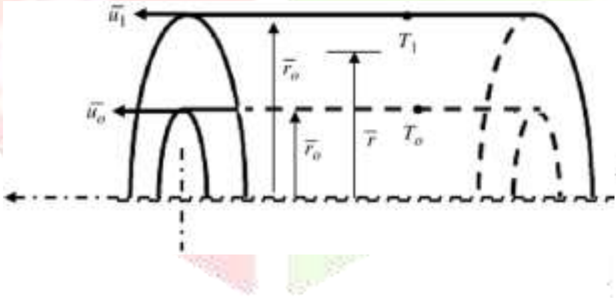
Knudsen number (Kn) relates the sub-atomic mean free way of gas to a trademark measurement of the channel. Knudsen number is exceptionally little for continuum flows. In any case, for microscale gas flows where the gas mean free way ends up practically identical with the trademark dimen-sion of the pipe, the Knudsen number might be more noteworthy than $10 - 3$. Microchannels with trademark lengths on the request of 100 μm would create flows inside the slip routine for gas with a regular mean free way of around

100 nm at standard conditions. The slip flow routine to be examined here is classified . At the point when the atomic mean free way is practically identical to the channel's trademark measurement, the continuum supposition that is never again legitimate and the gas displays non-continuum impacts, for example, speed slip and temperature seize the channel dividers. Conventional instances of non-continuum gas flows in channels incorporate low-thickness applica-tions, for example, high-elevation air ship or vacuum innovation. The ongoing advancement of microscale fluid frameworks has persuaded incredible enthusiasm for this field of study. Microfluidic frameworks must consider noncontinuum impacts. There is solid proof to help the utilization of Navier–Stirs and vitality conditions to show the slip flow issue, while the limit conditions are modified by including speed slip and temperature seize the channel dividers [1–4]. The little length scales normally experienced in microfluidic gadgets recommend that rarefaction impacts are significant. For instance, tries con-ducted by Arkilic et al. [2,3], Liu et al. [4], Pfalher et al. [5,6], Harley et al. [7], Choi et al. [8], and Wu et al. [9]. The flows considered by Arkilic et al. [2,3] are for the most part inside the slip flow routine, just circumscribing the change routine close to the outlet. When utilizing the Navier–Feeds conditions with slip flow limit conditions, the model had the option to foresee the flow precisely. Liu et al. [4] has additionally demonstrated that the answer for the Navier–Stirs condition joined with slip flow limit conditions show great concurrence with the trial information in microchannel flows. The systematic investigation of interior flows with slip already has been confined to straightforward geometries.

= ϕðRÞ−1 = −Kn Ω Q jr =R ð3c; dÞ

uniform divider temperature utilizing continuum hypothesis subject to slip speed and temperature hop limit conditions. The slip flow issue in microtubes has been generally led by examiners [15–18]. In any case, slip flow in microchannels has not been directed as much as the slip flow in microtubes. Since the slip flow in microchannels requires a two-dimensional methodology, its answer is generally difficult contrasted with that of the slip flow in microtubes. A portion of the slip flow contemplates in microchannels are outlined here.

where the right hand side of Eq. (3a,b) and (3c,d) represents the slip



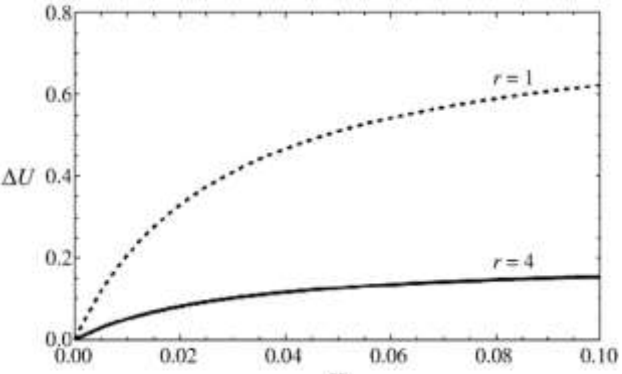


Fig. 1. Schematic diagram of the prob

Fig. 2. Effect of *Kn* on the velocity di

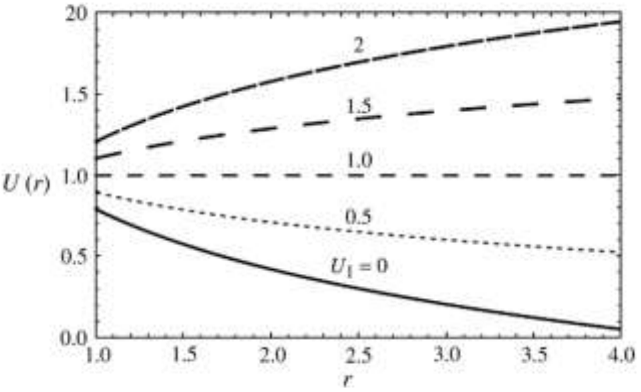


Fig. 3. Special velocity distribution at different U_1, $Kn = 0.01$ and $R = 4$.

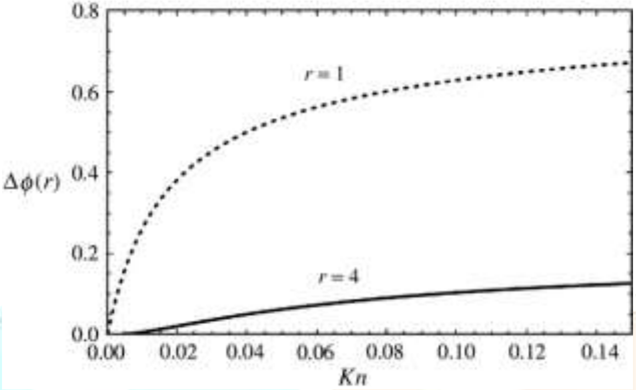


Fig. 5. Effect of *Kn* on the temperature difference at the inner and outer cylinder walls.

$U_1 = 0.$ in the hydrodynamic and thermal boundary condition of the boundary.

According to the boundary conditions given in Eq. (2a,b), the solution to the *z*-momentum equation (Eq. (1a)) is solved to give,

$$U(r) = \frac{kn\,(1 + R\,U_1)\,\delta + R\,(U_1 - 1)\,\mathrm{Log}[r] + R\,\mathrm{Log}[R]}{(kn\,(1 + R)\,\delta + R\,\mathrm{Log}[R])}, \qquad (4)$$

If the velocity distribution of Eq. (4) is substituted together with the temperature boundary conditions, Eq. (2c,d),) into the energy equation in Eq. (1b), the temperature distribution may be found as follows:

The math course of solving the algebraic equations that corre- spond to the boundary conditions was overwhelming, a symbolic algebraic equation solver code was used for this purpose.

2. Results and discussion

Base line parameters of the considered problem were $Pr = 0.7$, $\sigma_v = 0.05$, $R = 5$, $U_o = 1$, $Kn = 0.05$, and the Brinkman number $B = \mu\bar{u}^2/k\,(T_1 - T_O)$ is taken to be $B = 4$. In all figures of the results, the conventional no slip problem solutions of the base line parameters, $Kn = 0$ were drawn as a bold curves and are presented here for sake of comparison.

Fig. 2 shows the effect of Knudson number *Kn* on the slip velocity at the boundaries. It is clear that from this figure that as *Kn* increases,

have the same velocity, the fluid and cylinders move as a rigid body, hence, no chance for velocity slip.

Fig. 5 shows the effect of Knudson number *Kn* on the temperature jump at the boundaries. As shown from this figure, increasing *Kn* yields an increase in the temperature jump at the heated wall. This is due to the reduction in the interaction between the gas molecules and the heated wall. As *Kn* number increases, the mean free path length of the gas molecules increases which implies that any molecule reflected from the wall has less opportunity to collide with other molecules and then to transmit it to the wall heating effect. Larger *Kn* implies fewer molecules collide with the wall and carry part of its heating effect. As a result of increasing the temperature jump at the wall, less heat is transmitted to the gas, which yields less buoyancy driving force.

Effect of the outer cylinder velocity U_1 on the temperature jump at the inner and outer cylinder walls for adiabatic outer cylinder is shown in Fig. 6. It seems from this figure that the effect of the variations of the outer cylinder velocity U_1 on the temperature jump is insignificant but the jump in the inner surface is much larger than that of the outer surface.

3. Conclusions

In this study, the theoretically predicting method for heat transfer and hydrodynamic behaviors of fluid flow in axially moving micro- concentric cylinders in the slip flow and temperature jump regime are studied. It is found that as *Kn* increases the slip in the hydrodynamic and thermal boundary condition increases. Also, it is found that the slip velocity and the temperature jump at the inner surface are much larger than that of the outer one. The slip velocity and decreases with increases the outer cylinder velocity U_1 until its value reaches the inner cylinder velocity U_o, at this instant no slip no jump, after that increasing U_1 will increase the slip velocity. Also, it is found that the effect of the variation of U_1 on the temperature jump of the inner and outer cylinder surfaces for adiabatic outer surface is insignificant.

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