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Review on Dimensionless Number

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ABSTRACT: Dimensionless numbers are of key importance in parametric analysis of engineering problems. They're also extremely useful in understanding the similarity among problems belonging to an equivalent broad class. However, in spite of its importance in phenomenological analysis, their physical interpretation is typically not given or is contradictory within the literature. Well-known dimensionless numbers, like Re and Ra, are frequently misinterpreted in textbooks widely employed by engineering students. The main goal of this paper is to present a physical interpretation of the Reynolds, Peclet, Rayleigh and Boussinesq numbers supported the ratio of advective and diffusive fluxes of warmth and momentum. With the assistance of scale analysis it's shown that when the dimensionless numbers are associated with the ratio of advective and diffusive fluxes, the physical meaning is straightforward.

KEYWORDS: Dimensionless numbers, Peclet, Reynolds, Rayleigh.

INTRODUCTION

Dimensional numbers decrease the number of variables that characterize the structure, thereby decreasing the amount of experimental evidence needed to create connections between physical objects and scalable structures. The most famous dimensionless category in fluid mechanics is the number Reynolds (Re), named after the Osborne Reynolds who published a series of papers explaining the flow in pipes. It represents the ratio of the inertial forces to the viscous forces, where the density of the fluid is turbid, u is the mean velocity of the fluid, Dh is the cross-section length of the structure, and μ is the elastic viscosity of the fluid.

The use of dimensionless numbers in engineering and physics allows the important task of knowledge reduction of comparable problems. This suggests that tons of experimental runs are avoided if data is correlated using appropriate dimensionless parameters. Recall, for example, the transient 1D heat conduction during a slab with a convection boundary condition. During this case, the parameters involved are the slab thickness (L), conductivity (k), heat (cp), density (ρ), heat convection coefficient (h), temperature (T) and a space coordinate (x). Using dimensionless numbers the temperature dependence of six parameters reduces to a dependency of Biot, Fourier and x/L. Besides this fundamental application of the dimensionless numbers, they also function a crucial mechanism for understanding the physics of the phenomenon.

There are two widely used ways for obtaining the dimensionless numbers[1]. The first one is that the use of the well-known π-theorem , where it's , first, chosen the important variables of the physical process, including physical properties, geometry and flow variables, followed by the answer of a linear system for determining the exponents of the various variables which form the dimensionless numbers. This procedure requires foreknowledge, since if some important variable is forgotten, its influence within the dimensionless numbers is missed[2]. And, missing a crucial parameter may end in the looks of meaningless dimensionless numbers, which might correlate the physics of a non-existing phenomenon[3]. The second approach for determining dimensionless numbers is thru the utilization of the partial differential equations governing the physical phenomena. The key issue during this approach is that the definition of the dimensionless dependent and independent variables. An honest choice is required to finish up in dimensionless numbers that properly correlate the physical data[4].

In both procedures the dimensionless numbers just begin of the algebraic manipulation, lacking a robust physical interpretation. A better check out the areas of fluid mechanics and warmth transfer reveals that in these fields important dimensionless parameters like Reynolds, Peclet and Rayleigh are frequently misinterpreted. Using scale analysis, made strong contribution in clarifying several important aspects associated with these numbers[5]. In this work it's presented a physical interpretation of the Reynolds, Peclet, Rayleigh and Boussinesq numbers using scale analysis in conjunction with the role played by the advection and diffusion of momentum and energy in fluid flows.

The dimensional parameters that were utilized in the development of the dimensionless parameters in Table 9.8 are the characteristics of the system. Therefore there are several definition of Reynolds number. In fact, within the study of the physical situations often people refers to local Re number and therefore the global Re number. Keeping now in mind, there several typical dimensions which require to be mentioned. the standard body force is that the gravity g which features a direction to center of Earth. the standard length is denoted as ℓ and in many cases it's mentioned because the diameter or the radius. The density, ρ is mentioned the characteristic density or density at infinity. The area, A in drag and lift coefficients is referred normally to projected area.

The frequency ω or f is mentioned because the "unsteadiness" of the system. Generally, the periodic effect is enforced by the boundary conditions or the initial conditions. In other situations, the physics itself in stores or forces periodic instability. For instance, flow around cylinder initially seems like symmetrical situation. And indeed during a low Reynolds number it's a gentle state. However after a particular value of Reynolds number, vortexes are created in an infinite parade and this phenomenon is named Von Karman Vortex Street. These vortexes are created during a non–symmetrical way and hence create an unsteady situation. When Reynolds number increases, these vortexes are mixed and therefore the flow becomes turbulent which, are often considered a gentle state. The pressure P is that the pressure at infinity or when the speed is at rest. c is that the speed of sound of the fluid at rest or characteristic value. The worth of the viscosity, μ is usually some kind averaged value. The lack to define a fix value leads also to new dimensionless numbers which represent the deviations of those properties.

Dimensionless Numbers:

1.1 Reynolds number: represents the ratio between inertial and viscous forces. it's mainly wont to define the transition from laminar to flow [6]. At the method scale, the Reynolds number are often very large (> 106).

1.2 Schmidt number: represents the ratio between the rates of momentum transport and mass transport (diffusion) thanks to molecular motion. [7] it’s mainly wont to quantify the relative

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timescales and length scales of viscous momentum transport and diffusive mass transport. In gases, the Schmidt number is of order of unity, while within the liquids, it's usually very large (> 1000).

1.3 Prandtl number: where k is that the conductivity of the fluid and cp is restricted heat at constant pressure, represents the ratio between the rates of momentum transport and energy transport (conduction) thanks to molecular motion. In most fluids (gases and liquids), the Prandtl number is of order of unity.

1.4 Lewis number: represents the ratio between the rates of mass transport (diffusion) and energy transport (conduction) thanks to molecular motion.

It is important to remind the reader that Scш, Pr, and Le5-007 are dimensionless numbers described on the basis of the molecular properties of the fluid, that is, the characteristics of the fluid. By contrast, the macroscopic Reynolds number Re depends not only on the properties of the fluid, but also on the geometry of the device under investigation. The definition of the Reynolds number is thus system-dependent, and therefore Re would typically adjust during the scale-up.

Benefit of Dimensionless Numbers:

The benefit of dimensionless numbers can be summed up as follows:

A less difficult mathematical strategy can be utilized when the idea of dimensionless numbers is applied. Since first request boundaries are utilized to a bigger degree with this methodology, the issues related with union and steadiness become little. However, maybe the most appealing bit of leeway is that by changing the dimensionless numbers each significant degree in turn, say from 1 to 10 to 100, impacts of four boundaries all at once can be noticed. It is, for example, simple to notice impacts of conductivity (carbon fiber contrasted and glass fiber fortification), material thickness (thick versus flimsy overlays) and trademark time (examination among epoxy and polyester or various epoxies). Likewise a similar model can undoubtedly be reached out to show pultrusion, RTM and fiber winding.

As indicated by the material and mathematical qualities of the covers, there are a few cases where the warmth move and the active conduct can be depicted by more straightforward models. Broyer and Macosko97 have demonstrated that, if the thickness of a thermosetting material is expanded over a basic worth, the awkwardness between the warmth age and the warm diffusivity of the framework during handling prompts a for all intents and purposes adiabatic circumstance.

LITERATURE REVIEW

The use of dimensionless numbers in engineering and physics allows the important task of knowledge reduction of comparable problems. This suggests that tons of experimental runs are avoided if data is correlated using appropriate dimensionless parameters[8].

The most famous dimensionless category in fluid mechanics is the number Reynolds (Re), named after the Osborne Reynolds who published a series of papers explaining the flow in pipes. It represents the ratio of the inertial forces to the viscous forces, where the density of the fluid is turbid, u is the mean velocity of the fluid, Dh is the cross-section length of the structure, and μ is the elastic viscosity of the fluid[5].

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CONCLUSION

This paper provided a physical interpretation of some of the most significant ones Dimensionless numbers used in fluid dynamics and heat transfer, such as Reynolds and Rayleigh numbers. The description focused on the relative significance of advection/diffusion transfer processes and on a scale analysis makes for a simple understanding of the numbers of Reynolds, Peclet and Rayleigh. The dimensionless numbers described in this way make it easy to interpret simple physical processes as well as to better understand certain physical assumptions, such as those made in boundary layer flows. It also helps to understand the function of the characteristic length of each dimensionless number.

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