

Heat, Mass, and Momentum Transfer Analogies for the Fully Developed Turbulent Flow of Power Law Fluids in Circular Tubes

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A new correlation is presented to describe heat and mass transfer at large Prandtl or Schmidt numbers to power law fluids in fully developed turbulent flow in a pipe. The resulting expression for the Stanton number differs from earlier semiempirical correlations in that it is based on a continuous eddy viscosity distribution from the wall to the center of the pipe and contains no adjustable parameters to be determined from heat transfer data. Nusselt numbers determined by the new correlation are in excellent agreement with data on heat transfer to both pseudoplastic and dilatant fluids.

Excellent reviews of the available correlations for heat and mass transfer to inelastic, time-independent, non-Newtonian fluids in fully developed turbulent pipe flow are given by Metzner (18) and Skelland (31). The most widely used correlation to date has been that of Metzner and Friend (19), who extended the theoretical analogy of Reichardt (27) to purely viscous non-Newtonian fluids to obtain the following equation for the Nusselt number:

$$N_{Nu} = \frac{f/2}{1.20 + c\sqrt{f/2}} N_{Re} N_{Pr} \quad (1)$$

The parameters of the constitutive equation for the non-Newtonian fluid enter Equation (1) through the friction factor f , the non-Newtonian generalized Reynolds number N_{Re} , the generalized Prandtl number N_{Pr} , and the empirical function c , which in the general case also may be a function of the generalized non-Newtonian Reynolds number. These investigators determined c empirically from experimental heat transfer coefficients for both pseudoplastic and Newtonian fluids. Their final correlation has the form

$$N_{Nu} = \frac{f/2}{1.20 + 11.8 \sqrt{f/2} (N_{Prw} - 1) (N_{Prw})^{-1/4}} N_{Re} N_{Pr} \quad (2)$$

The Prandtl number at the wall N_{Prw} is related to the generalized Prandtl number as follows:

$$\frac{N_{Pr}}{N_{Prw}} = \left(\frac{16}{N_{Re} f} \right)^{\frac{n-1}{n}} \left(\frac{3n+1}{4n} \right) \quad (3)$$

In developing the above, the rheological behavior of the purely viscous non-Newtonian fluids was represented by the empirical Ostwald-de Waele or power law constitutive

equation

$$\tau = - \left\{ K \left| \sqrt{\frac{1}{2} (\Delta : \Delta)} \right|^{n-1} \right\} \Delta \quad (4)$$

This was chosen in view of its proved ability to portray experimental data over moderately large ranges of shear rate for many systems.

Equation (2) is restricted to nearly isothermal flow. Petersen and Christiansen (25) have extended Metzner and Friend's correlation to nonisothermal and transitional flow. These same authors have argued that the Prandtl number to be used in Equation (2) should be corrected for the fact that the effective viscosity in the wall region is less than that in the turbulent core for pseudoplastic fluids. They suggest that the following effective Prandtl number be used in Equation (2):

$$N_{Prw} = \frac{808(n+2)^{0.6+0.1/(n-1)}}{1,055(3n+1)} N_{Prw} \quad (5)$$

Clapp (4) extended Martinelli's (17) analogy to power law fluids. However, the Nusselt numbers predicted were considerably lower than those he observed for pseudoplastic fluids in the range $0.7 < n < 0.8$. He proposed the empirical equation

$$N_{Nu} = 0.023 (9350)^{0.821-1/(n+0.9)} (N_{Re})^{0.67/(n+0.9)} (N_{Pr})^{0.4} \quad (6)$$

Mizushima and Kuriwaki (30) recently correlated their heat transfer data on both pseudoplastic and dilatant fluids with a modified form of the Chilton-Colburn (3) equation:

$$N_{Nu} = (0.023)^{0.6+0.25/(2.06n+1.0)} (N_{Re})^{0.6+0.25/(2.06n+1.0)} (N_{Pr})^{1/3} \quad (7)$$

Recently, Hughmark (10) has extended Longwell's (15) equation to power law fluids. The mean velocity profile is

Momentum Transfer In Fluids

C P Kothandaraman, R Rudramoorthy



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Momentum Transfer in Fluids Wm.H. Corcoran,2012-12-02 Momentum Transfer in Fluids provides information pertinent to fluid mechanics This book discusses several topics related to the movement of fluids including boundary layer analysis statistical treatment of turbulence as well as laminar and turbulent shear flow Comprised of seven chapters this book starts with an overview of the physical nature of momentum and describes the application of this concept to systems of variable weight which are useful in the prediction of the physical behavior of fluids in motion This text then explores the fundamental properties and the macroscopic aspects of turbulent flow Other chapters present the significance and utility of mixing length and other macroscopic turbulence parameters This book discusses as well the prediction of the velocity and friction as functions of position in the flowing stream The final chapter deals with the qualitative aspects of boundary flows for compressible and incompressible fluids This book is a valuable resource for scientists and chemical engineers

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Hydraulic Machines Bansal, 2005-12-30 **Thermophysical Properties of Nanofluids** Valery Rudyak, 2025-09-04 This book offers a modern look at transport processes in nanofluids highlighting their unique properties and broad applications beyond thermal engineering The author presents independent systematic data on all known types of nanofluids derived from numerous experiments measuring transport coefficients The book unambiguously formulates conclusions regarding the dependence of these coefficients on various factors such as nanoparticle concentration size type and base fluid The author shows mechanisms of transport processes through molecular dynamic modeling performed alongside experiments and systematically studies the rheology of simple liquids and nanofluids The chapter on hydrodynamic modeling of nanofluid flows emphasizes caution discussing the limitations of using similarity criteria Special data are accompanied by preliminary discussions of transport processes in simple and coarse dispersed liquids making the book accessible and interesting for students graduate students engineers and researchers **Heat, Mass, and Momentum Transfer** Warren M. Rohsenow, Harry Y. Choi, 1961 **Proceedings of the ASME Heat Transfer and Fluids Engineering Divisions** American Society of Mechanical Engineers. Heat Transfer Division, American Society of Mechanical Engineers. Fluids Engineering Division, 1995 Basics of Research Writing in Computational Fluid Dynamics Buddhi Prasad Sapkota, PhD, 2025-08-12 Computational Fluid Dynamics CFD is developing rapidly becoming an essential interface between theoretical and applied fluid mechanics through numerical simulations With the increasing availability and use of CFD tools the importance of effective technical writing has become paramount whether for well structured papers theses or technical reports This book Basics of Research Writing in Computational Fluid Dynamics aims to equip students researchers and professionals with the skills needed to communicate CFD work effectively While not a comprehensive guide to CFD theory or numerical methods though fundamental concepts are introduced where necessary this book focuses specifically on the writing process for CFD research developing conceptual understanding and procedural skills crafting abstracts methods results and discussion sections and proper use of literature algorithms validation data and software This book serves as a valuable resource for graduate students writing theses or dissertations involving CFD early career researchers preparing journal articles or conference papers industry professionals documenting simulation work in technical reports non native English speakers navigating CFD terminology in academic writing and students and practitioners across mathematics engineering and physics The book includes annotated examples from published CFD literature clear definitions of key terms and concepts step by step guides for scientific writing I extend my sincere gratitude to the global CFD community particularly reviewers and editors open source developers advancing the field colleagues who shared drafts and reviews and Booksclinic Publishing for their support This book serves as a starting point for research communication True mastery develops through practice peer feedback and engagement with scientific literature While every effort has been made to ensure accuracy I welcome suggestions for improvement in future editions *Bioprocess Engineering Principles* Pauline M.

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Bear,2018-01-25 This book presents and discusses the construction of mathematical models that describe phenomena of flow and transport in porous media as encountered in civil and environmental engineering petroleum and agricultural engineering as well as chemical and geothermal engineering The phenomena of transport of extensive quantities like mass of fluid phases mass of chemical species dissolved in fluid phases momentum and energy of the solid matrix and of fluid phases occupying the void space of porous medium domains are encountered in all these disciplines The book which can also serve as a text for courses on modeling in these disciplines starts from first principles and focuses on the construction of well posed mathematical models that describe all these transport phenomena Fundamentals of Fluid Mechanics and Machinery Mr.

Sanjeev Pandey,2024-08-16 Covers theoretical and practical aspects of fluid flow and its application in various engineering machines emphasizing performance analysis and design considerations Basic Fluid Mechanics C P Kothandaraman,R

Rudramoorthy, Heat Transfer Exam Study Essentials Cybellium,2024-10-26 Designed for professionals students and enthusiasts alike our comprehensive books empower you to stay ahead in a rapidly evolving digital world Expert Insights Our books provide deep actionable insights that bridge the gap between theory and practical application Up to Date Content Stay current with the latest advancements trends and best practices in IT AI Cybersecurity Business Economics and Science Each guide is regularly updated to reflect the newest developments and challenges Comprehensive Coverage Whether you re a beginner or an advanced learner Cybellium books cover a wide range of topics from foundational principles to specialized knowledge tailored to your level of expertise Become part of a global network of learners and professionals who trust Cybellium to guide their educational journey www.cybellium.com

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