Filtration In Porous Media And Industrial Application Lectures Given At The 4th Session Of The Centro Internazionale Matematico Estivo Cime 24 29 1998 Lecture Notes In Mathematics

Filtration in Porous Media and Industrial ApplicationLectures given at the 4th Session of the Centro Internazionale

Matematico Estivo (C.I.M.E.) held in Cetraro, Italy, August 24-29, 1998Springer

Particle retention in porous media occurs in many natural and environmental settings, such as waste-water purification, contaminants dispersion, fines migration and more. In petroleum engineering, particle retention (e.g. drilling mud invasion, produced water re-injection, polymer retention) will induce permeability decline and formation damage. Existing macroscopic models often fail to be predictive without empirical adjustments. A

predictive micro-scale model of particle filtration is of great significance to the control of formation damage and to the economical exploitation of hydrocarbon reservoirs. In this work, a Lagrangian pore network model has been developed for particle deposition. The model tracks the transport trajectory of each individual particle in porous media. It is able to capture the complex particle-surface interaction during deposition and has been validated against published experimental data. A new gravity number is developed to better scale the

filtration coefficient. The particle size distribution is found to be one of the causes of hyperexponential deposition. The permeability decline not only depends on the volume of deposited particles, but also on the surface charge. In addition, an Eulerian pore network model has been developed for particle jamming in porous media. The probabilistic nature of jamming has been systematically studied using a Discrete Element Method (DEM). Based on the DEM simulations, a unified model for the jamming probability has been created, which is able to

predict the effect of friction, pore/particle size ratio, and particle concentration on jamming. The numerical results achieved good agreement with direct CFD-DEM and particle flooding experiments. We then combine the Eulerian model with a deposition model to predict polymer adsorption and mechanical entrapment in porous media. The hydraulic conductivity of a fouled cylindrical tube is updated using models that are created based on CFD simulations. It is found that the longitudinal dispersivity is larger breakthrough curve broader

than a Newtonian fluid for a power-law fluid with constant rheological properties. However, if the power-law parameters are functions of polymer concentration, the breakthrough curve is narrower than a Newtonian fluid because fluid is concentrated and thus more viscous in the fast flow paths. For particle retention, fluids with a high shear-thinning index result in more permeability reduction. For Bingham plastic fluids with concentration independent rheological properties, breakthrough occurs earlier as yield stress increases because

the number of the dead-end or isolated pores increases. Compared with a Newtonian fluid, flow of a Bingham plastic fluid results in less jamming because particles are unable to enter the smaller pore throats that are closed to flow.

Solution of Filtration Problems Through Porous Media. The Programs PIGRA, DAMIAN, PLOTDAM.

Lectures Given at the 4th Session of the Centro Internazionale Matematico Estivo (C.I.M.E.) Held in Cetraro, Italy, August 24-29, 1998

Nonstationary Filtration in

Partially Saturated Porous Media

An Investigation of the Influence of Some Physico-chemical Variables on Porous Media Filtration

Emerging Technologies and Techniques in Porous Media

This book examines the relationship between transport properties and pore structure of porous material. Models of pore structure are presented with a discussion of how such models can be used to predict the transport properties of porous media. Portions of the book are devoted to interpretations of experimental results in this area and directions

for future research. Practical applications are given where applicable, and are expected to be useful for a large number of different fields, including reservoir engineering, geology, hydrogeology, soil science, chemical process engineering, biomedical engineering, fuel technology, hydrometallurgy, nuclear reactor technology, and materials science. Presents mechanisms of immiscible and miscible displacement (hydrodynamic dispersion) process in porous media Examines relationships between pore structure and fluid transport Considers approaches to enhanced oil recovery Explores network

modeling and perolation theory Heat and fluid flow in fluid-saturated porous media has become increas ingly more attractive to researchers and thus it has become a very pro ductive field for many researchers and practical engineers in very diverse range of fields. The great interest in the topic stems from its widespread number of different practical applications in modern industries and in many environmental issues, such as nuclear waste management, build ing thermal insulators, geothermal power plants, grain storage, etc. In building sciences and thermal insulation engineering, an appreciable in sulating effect has been derived by placing porous

material in the gap between the cavity walls and multishield structures of nuclear reactors between the pressure vessel and the reactor. Geophysical applications include modeling of the spread of pollutants (e. g. radioactive mater ial), water movements in geothermal reservoirs, enhanced recovery of petroleum reservoirs, etc. These, and many other, important practical applications have resulted in a rapid expansion of research in the general area of porous media and thus generated a vast amount of both theor etical and experimental research work. It has attracted the attention of industrialists, engineers and scientists from many varying

disciplines, such as applied mathematics, chemical, civil, environmental, mechanical and nuclear engineering, geothermal physics, food science, medicine, etc. This book contains some of the contributions to the NATO Advanced Study Institute on Emerging Technologies and Techniques in Porous Media that was held in Neptun-Olimp, Constanta, Black Sea, Romania on 9-20 June, 2003.

Porous Media

Flow Through Compressible Porous Media : Short-time Filtration, Wall Friction in Compression-permeability Cells, and Rheological Models

Particle Transport in Flow Through

Porous Media

Porous Media Fluid Transport and Pore Structure

Fluid Transport and Pore Structure

The fluid flow in fracture porous media plays a significant role in the assessment of deep underground reservoirs, such as through CO2 sequestration, enhanced oil recovery, and geothermal energy development. Many methods have been employed—from laboratory experimentation to theoretical analysis and numerical simulations—and allowed for many useful conclusions. This Special Issue aims to report on the current

advances related to this topic. This collection of 58 papers represents a wide variety of topics, including on granite permeability investigation, grouting, coal mining, roadway, and concrete, to name but a few. We sincerely hope that the papers published in this Special Issue will be an invaluable resource for our readers.

Porous Media: Fluid Transport and Pore Structure presents relevant data on the role of pore structure in terms of transport phenomena in pore spaces. The information is then applied to the interpretation of various experiments and results of

model calculations. This book emphasizes the discussion of ""flow through porous media"" in terms of interactions among the three main factors. These factors are transport phenomena, interfacial effects, and pore structure. An introductory chapter opens the text and presents some of the basic concepts and terms that will be encountered all throughout. Chapters 2 to 4 focus on the important foundations of the physical phenomena as applied in the pore space of porous media. These foundations are capillarity, pore structure, and

single phase flow and diffusion. Chapters 5 to 7 discuss more in detail the different applications of pore structure to various operations and processes. Some of the concepts covered in this part of the book include flow and/or diffusion through a porous medium, simultaneous flow of immiscible fluids and immiscible displacement, and miscible displacement and hydrodynamic dispersion. This book is a good reference to students, scientists, and engineers in the field of chemistry, physics, and biology.

A New Model for Granular Porous Media

Acoustically Driven Filtration of Particulate Suspensions in Porous Media

Theory and Mechanism of Filtration on Non-colloidal Fines Through a Porous Media

Mathematical Models for Filtration Through Porous Media

Structural Properties of Porous Materials and Powders Used in Different Fields of Science and Technology

This volume contains the lectures presented at the NATO ADVANCED STUDY INSTITUTE that took place at Newark, Delaware, U. S. A. , July 14-23, 1985. The objective of this meeting

was to present and discuss selected topics associated with transport phenomena in porous media. By their very nature, porous media and phenomena of transport of extensive quantities that take place in them, are very complex. The solid matrix may be rigid, or deformable (elastically, or following some other constitutive relation), the void space may be occupied by one or more fluid phases. Each fluid phase may be composed of more than one component, with the various components capable

of interacting among themselves and/or with the solid matrix. The transport process may be isothermal or non-isothermal, with or without phase changes. Porous medium domains in which extensive quantities, such as mass of a fluid phase, component of a fluid phase, or heat of the porous medium as a whole, are being transported occur in the practice in a variety of disciplines. This book focuses on the effects of the material, porosity, pore size and

pore shape on flow behaviour and heat transfer in microscale porous media manufactured using a space holder method. It also describes a novel approach to studying flow behaviour in non-transparent materials such as porous metals via flow visualization in transparent media that mimic the porous structure. The book employs a combination of microparticle image velocimetry - a modern, advanced technique - and pressure drop measurement - a more traditional

method - that makes the mechanistic study of several phenomena possible. It covers the identification of various flow regimes and their boundaries, velocity profiles on the microscale, the heat transfer coefficient under forced convection, and the correlation between flow behaviour on the pore scale and the convective heat transfer performance of the porous media. Understanding the fundamentals of porous flow, especially on the microscale, is critical

for applications of porous media in heat exchangers, catalytic convertors, chemical reactors, filtration and oil extraction. Accordingly, this book offers a valuable resource for all researchers, graduate students and engineers working in the areas of porous flow and porous materials.

Theory of Hydraulic Models

A Fast Inverse Solver for the Filtration Function for Flow of Water with Particles in Porous Media

Lectures given at the 4th Session of the Centro

Internazionale Matematico Estivo (C.I.M.E.) held in Cetraro, Italy, August 24-29, 1998

Flow Through Porous Media ; "wall Friction" in Filtration

Filters and Filtration Handbook

In this thesis, we studied numerical methods for the coupling of free fluid flow with porous medium flow. The free fluid flow is modelled by the Stokes equations while the flow in the porous medium is modelled by Darcy's law. Appropriate conditions are imposed at the interface between the two regions. The weak formulation of the problem is based on mixed-

formulation for Stokes and on a primal-mixed formulation for Darcy equation, incorporating in a natural way the interface conditions. The finite element discretization of the problem leads to large, sparse and ill-conditioned algebraic system to be solved for velocities in both domains, Stokes pressure and piezometric head in porous domain. The system is reduced to interface systems for the normal velocity and piezometric head by a Schur complement approach. We present numerical results for several solution methods based on different preconditioning techniques for the solution of the interface systems. We study the effectiveness of the preconditioners with respect to

mesh refinement and physical parameters. An application to cross-flow membranes has been considered. Finally, we also assess the numerical accuracy of an uncoupled algorithm for transient problem, which uses different time steps in the Stokes and in the Darcy domains.

For graduate students, research workers and practising engineers in the design of hydraulic structures and designing water works.

Applications to Filtration Through Packed Beds

Solutions of Potential Fields Using Flexible Finite Element Methods with Applications in Flow Through Porous Media and Electrospinning

The dependence of the filtration velocity in porous media on some physical constants

The Inverse Problem of Determining the Filtration Function and Permeability Reduction in Flow of Water with Particles in Porous Media

Filters are used in most industries, especially the water, sewage, oil, gas, food and beverage, and pharmaceutical industries. The new edition of this established title is an all-encompassing practical account of standard filtration equipment and its applications. Completely revised and rewritten, it is an essential book for the

engineer working in a plant situation-who requires guidance and information on what's available and whether it's suitable for the job. Co-published with the Institution of Chemical Engineers. Co-published with the Institution of Chemical Engineers. The leading practical engineering guide to filtration techniques, systems and their applications Meets the needs of all key sectors where filtration is a critical process, including chemical processing and manufacture, food, oil and gas, air-conditioning and water A comprehensive sourcebook and reference for plant

engineers, process engineers, plant designers, filter media and filtration specialists and equipment specifiers.

This book is devoted to the presentation of some flow problems in porous media having relevant industrial applications. The main topics covered are: the manufacturing of composite materials, the espresso coffee brewing process, the filtration of liquids through diapers, various questions about flow problems in oil reservoirs and the theory of homogenization. The aim is to show that filtration problems arising in very

practical industrial context exhibit interesting and highly nontrivial mathematical aspects. Thus the style of the book is mathematically rigorous, but specifically oriented towards applications, so that it is intended for both applied mathematicians and researchers in various areas of technological interest. The reader is required to have a good knowledge of the classical theory of PDE and basic functional analysis. Multiphase Constitutive Theory for Porous Media with Applications to Filtration Fluid Flow and Heat Transfer in Porous Media Manufactured by a Space Holder Method

Filtration in Porous Media and Industrial Application
A Study of Some Chemical Parameters Influencing
Porous Media Filtration
Particle Clogging in Porous Media

The purpose of this book, Industrial and Technological Applications of Transport in Porous Materials, is to provide a collection of recent contributions in the field of heat and mass transfer in porous media and their industrial and technological applications. The main benefit of the book is

that it discusses some of the most important topics related to transport phenomenon in engineering and their future applications. It includes a set of new technological applications in the field of heat and mass transfer phenomena in a porous medium domain, such as, drying technology, filtration, infrared thermography, energy, recycling, etc. At the same time, these topics will be going to the encounter of a variety of

scientific and engineering disciplines, such as chemical, civil, agricultural, mechanical engineering, etc. The book is divided in several chapters that intend to be a resume of the current state of knowledge for benefit of professional colleagues. This book, "Heat and Mass Transfer in Porous Media", presents a set of new developments in the field of basic and applied research work on the physical and chemical aspects of heat and mass

transfer phenomena in a porous medium domain, as well as related material properties and their measurements. The book contents include both theoretical and experimental developments, providing a self-contained major reference that is appealing to both the scientists and the engineers. At the same time, these topics will encounter of a variety of scientific and engineering disciplines, such as chemical, civil,

agricultural, mechanical engineering, etc. The book is divided in several chapters that intend to be a short monograph in which the authors summarize the current state of knowledge for benefit of professionals.

Filtration Combustion of Methane and Hydrogen Sulfide in Inert Porous Media

Industrial and Technological Applications of Transport in Porous Materials

Coupled Pore-to-continuum Multiscale

Modeling of Dynamic Particle Filtration Processes in Porous Media

Pore-scale Modeling of Particle Filtration in Porous Media

Fluid Flow in Fractured Porous Media

This book provides a comprehensive and concise description of most important aspects of experimental and theoretical investigations of porous materials and powders, with the use and application of these materials in different fields of science, technology, national economy and environment. It allows the reader to understand the basic regularities of heat and mass

transfer and adsorption occurring in qualitatively different porous materials and products, and allows the reader to optimize the functional properties of porous and powdered products and materials. Written in an straightforward and transparent manner, this book is accessible to both experts and those without specialist knowledge, and it is further elucidated by drawings, schemes and photographs. Porous materials and powders with different pore sizes are used in many areas of industry, geology, agriculture and science. These areas include (i) a variety of devices and supplies; (ii) thermal insulation and building materials; (iii) oil-bearing geological, gas-bearing and water-bearing rocks; and (iv)

biological objects. Structural Properties of Porous Materials and Powders Used in Different Fields of Science and Technology is intended for a wide-ranging audience specializing in different fields of science and engineering including engineers, geologists, geophysicists, oil and gas producers, agronomists, physiologists, pharmacists, researchers, teachers and students. Filtration technology has found extensive applications in a variety of industries such as oil and gas, aerospace, automotive, agriculture, food processing and pharmaceutical industries. While numerous experimental approaches have been used to optimize the filtration performance, modeling approach is

playing an increasingly important role in filtration research as a complimentary tool to experiments. In gas-liquid filtration, a coalescing filter medium is installed in a holder placed in the middle of a long pipe in which the aerosol mixed gas flow passes through porous medium to get purified with aid of filter. Modeling the whole process requires the development of a coupled flow model that describe the flow dynamics in both free channel and porous media flow domain. A flexible finite element method using FlexPDE software was applied to simulate the flow field such as velocity and pressure profile in the full coupled flow domain including the interface between free channel and porous media. Multiphase

transport theory was introduced to set up property balance equations to model the species balance for different types of substances in gas and liquid phase. In this research, a feasible and effective approach has been proposed to model coupled free channel and porous medium flows over a wide range of permeabilities. In further study, a dynamic simulation of spatial and temporal transport phenomenon of aerosols through free channel and filter medium was developed on the basis of coupled flow model to describe the start-up and loading stage of gas-liquid filtration. A series of parametric study were carried out to evaluate the influence of a variety of factors on filtration performance. Modeling of coalescence phenomenon

was also investigated and some preliminary results showed a replication of `U' shape saturation profile during filtration process. This work contributes to a better understanding of coalescing filtration in terms of flow dynamics for different species, time-dependent saturation profile and mechanism of drop coalescence. Another application of FlexPDE simulation assisted in a precise and controlled production of electrospun nanofibers by modeling the 3 dimensional electrostatic field to forecast the trajectory of electrospinning jets. The model predictions achieved a good agreement with experimental results, demonstrating an effective computational approach to improve

the production efficiency in electrospinning process.

Heat and Mass Transfer in Porous Media

Flow of Fluids Through Porous Media. Application to Rotary Vacuum Filtration

Filtration of a Smectite Solution

Advection, Longitudinal Dispersion, and Filtration

Numerical Approximation of Filtration Processes Through Porous Media