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Complex Flows in Industrial Processes

Antonio Fasano
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With 102 Figures

Springer-Science+Business Media, LLC

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Library of Congress Cataloging-in-Publication Data

Fasano, A. (Antonio)

Complex flows in industrial processes / Antonio Fasano.

p. cm.—(Modeling and simulation in science, engineering
and technology)

Includes bibliographical references and index.

ISBN 978-1-4612-7106-2 ISBN 978-1-4612-1348-2 (eBook)

DOI 10.1007/978-1-4612-1348-2

1. Manufacturing processes—Mathematical models. 2. Fluid
dynamics—Mathematical models. I. Title. II. Series: Modeling in
science, engineering & technology.

TS183. F37 1999

658.5'001'5118—dc21

99-33030

CIP

AMS Subject Classifications: 76A, 76B, 76C, 76S, 80A

Printed on acid-free paper.

© 2000 Springer Science+Business Media New York

Originally published by Birkhauser Boston in 2000

Softcover reprint of the hardcover 1st edition 2000



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ISBN 978-1-4612-7106-2

SPIN 10682919

Typeset by TechBooks, Fairfax, VA.

9 8 7 6 5 4 3 2 1

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Preface

Despite the fact that fluid dynamics and filtration through porous media are classical research areas in engineering, physics, and mathematics, there are still many industrial processes that require the study of new mathematical models for flows of particular complexity, due to the peculiar properties of the systems involved.

The aim of this book is to provide a number of examples showing how frequently such situations arise in various branches of industrial technology. The selection of the subjects was motivated not only by their industrial relevance and mathematical interest. What I had in mind was a collection of problems having a really distinctive character, thus bringing some fresh air into one of the oldest and most revered domains of applied mathematics. The incredible richness of nonstandard flow problems in industrial applications has always been, and still is, a constant surprise to me. Therefore I tried to offer a very large spectrum of subjects, with special attention devoted to those problems in which the modeling phase is far from being obvious, and the mathematical content is absolutely nontrivial. With such a view to diversity, topics have been selected from a variety of sources (such as glass industry, polymers science, coffee brewing, fuels pipelining), and contributors from different backgrounds (mathematics, physics, chemical engineering) have been included. Consequently, the mathematical nature of the problems formulated spans over a large range, so that their theoretical investigation and numerical computation require a variety of different techniques.

Chapters have been grouped in three classes:

- i) “Flows of nonlinear materials” is a generic title emphasizing peculiar rheological properties (polymeric flows, stability problems in extrusion, and coal-water slurries).
- ii) “Flows accompanied by thermal processes” is a large class in which we have included specific problems such as phase change in polymers,

where the flow is thermally induced, various flow problems in the glass industry, and the flow fields that accompany mass and heat transfer in polymerization processes.

- iii) “Nonlinear flows in porous media” is another broad title we have chosen for a group of very peculiar processes which are in reality quite loosely related to one another, namely: espresso coffee brewing, the manufacturing of composite materials, and the flow of liquid through porous media with hydrophile granules. However, they do have a common denominator, which is the interaction of the flow with the solid components of the system.

Because of space constraints, we have chosen only a few illustrative examples. Many more problems of great relevance can be found in different areas. A remarkable case is the one of oil reservoir technology, a very rich source of important (and probably more widely known) mathematical problems, so large and fast developing that today we can consider it as a classical research field, for which an extensive literature exists, and that is in turn an inexhaustible collection of complex flow problems, whose size is out of the conceivable range of the present book.

Thus we are not pursuing any idea of completeness, which would certainly be a hopeless goal. The material gathered here is just a sampling from a big boiling pot, which I hope can be stimulating to those who like real world applications of fluid dynamics treated with mathematical rigor. For this reason quite a few open problems deserving further investigation have been included in each presentation.

I would like to thank Prof. Nicola Bellomo who encouraged me to be the editor of this book. Of course I am deeply grateful to all the authors who made the nontrivial effort to contribute a chapter on problems with such special characteristics.

Firenze, Italy

ANTONIO FASANO

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