

DRAG REDUCTION OF TURBULENT FLOWS BY ADDITIVES

FLUID MECHANICS AND ITS APPLICATIONS

Volume 32

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Aims and Scope of the Series

The purpose of this series is to focus on subjects in which fluid mechanics plays a fundamental role.

As well as the more traditional applications of aeronautics, hydraulics, heat and mass transfer etc., books will be published dealing with topics which are currently in a state of rapid development, such as turbulence, suspensions and multiphase fluids, super and hypersonic flows and numerical modelling techniques.

It is a widely held view that it is the interdisciplinary subjects that will receive intense scientific attention, bringing them to the forefront of technological advancement. Fluids have the ability to transport matter and its properties as well as transmit force, therefore fluid mechanics is a subject that is particularly open to cross fertilisation with other sciences and disciplines of engineering. The subject of fluid mechanics will be highly relevant in domains such as chemical, metallurgical, biological and ecological engineering. This series is particularly open to such new multidisciplinary domains.

The median level of presentation is the first year graduate student. Some texts are monographs defining the current state of a field; others are accessible to final year undergraduates; but essentially the emphasis is on readability and clarity.

For a list of related mechanics titles, see final pages.

Drag Reduction of Turbulent Flows by Additives

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Preface

In the present series several books have already been published on drag reduction in turbulent flows. These books deal with manipulations of turbulent flows by passive means, especially by attaching special roughness elements to the wall, e.g. riblet sheets. However, what has been missing is a description of the drag reduction in turbulent flows achieved by additives, whose efficiency is even higher than that produced by passive means.

Drag reduction by additives for fibres was discovered 60 years ago and 50 years ago for polymers and surfactants. Since the discovery of the effect there has been an up and down of the basic research and the testing of possible applications. This varying interest in the effect resulted from an overestimation of the possibilities of application and the resulting disappointments. Nevertheless, the effect is still of importance for two reasons:

1. In many cases it is easier to manipulate flows by additives than by passive means, and the potential of applications is considerable, as we will show.
2. The effect is of importance for the research on turbulence, because every drastic manipulation allows conclusions concerning the basic elements of a process.

This book covers both aspects, because continuation of the basic research and the applied research make worthwhile contributions. Thus it is the aim of the book to present the state of the art with respect to both aspects in order to motivate researchers doing basic research as well as doing applied research in the future. Consequently, this defines the readers. There is the researcher in the field of fluid mechanics to whom we will demonstrate in which respect research on this effect is important for the understanding of turbulent flows. On the other hand, there is the engineer who is looking for new, creative methods to develop energy-saving processes in which friction losses are of importance. Furthermore, we intend to give impulses as to how the knowledge of the effect can be useful for other areas of research in which fluid mechanics play a minor role, e.g. methods of irrigation in agriculture. Thus besides the basic research and the application of the effect the book is also interesting for people working in other fields and willing to integrate new ideas for their purposes.

Drag reduction by additives cannot be reduced to one effect and its explanation. Surprisingly, there are several effects which are very similar and result in the same outcome. Thus a broad description of the effect is essential.

The book is divided into three parts: In the first part basic knowledge is more broadly presented than necessary for the understanding of the following parts. This is done to enable the reader to develop and formulate his own thoughts. The second part of the book is the core part. In this part drag reduction by addition of polymers, surfactants, and fibres is presented. Relevant experimental results as well as theoretical attempts or hypotheses to explain the effect are presented. In the third part the potential of applications is discussed. It ends with a subchapter, in which several possible future applications are speculated at.

The book is based on the research results of the last 60 years. Consequently, many results and explanations were found several years ago. Thus the subject will not only be elucidated in view of the most recent publications in this field. Also older results, ideas, and explanations are included in order to gain a complete insight. This was taken into account by referring to older, original publications and resulted in an extensive list of references.

Finally, we hope that this book can help to point out how interesting the effect of drag reduction by additives is.

Zürich, Senftenberg

J a n u a r y

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