科技资料

Structure of Turbulence and Drag Reduction

International Union of Theoretical and Applied Mechanics

A. Gyr (Editor)

Structure of Turbulence and Drag Reduction

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Preface

In 1976 a similar titled IUTAM Symposium (Structure of Turbulence and Drag Reduction) was held in Washington . However, the progress made during the last thirteen years as well as the much promising current research desired a second one this year.

In Washington drag reduction by additives and by direct manipulation of the walls (compliant walls and heated surfaces) were discussed. In the meantime it became evident that drag reduction also occurs when turbulence is influenced by geometrical means, e.g. by influencing the pressure distribution by the shape of the body (airfoils) or by the introduction of streamwise perturbances on a body (riblets).

In the recent years turbulence research has seen increasing attention being focused on the investigation of coherent structures, mainly in Newtonian fluids. We all know that these structures are a significant feature of turbulent flows, playing an important role in the energy balance in such flows. However their place in turbulence theories as well as the factors influencing their development are still poorly understood. Consequently, the investigation of phenomena in which the properties of coherent structures are altered provides a promising means of improving our understanding of turbulent flows in general.

The mechanisms responsible for the phenomenon of turbulent drag reduction produced by the addition of polymers, surfactans, fibres, flakes, needles, algae, gas bubbles etc. deserve particular attention. A more detailed knowledge of coherent structures would also enable a better understanding of the influence of modified wall characteristics, in particuar the drag reducing effect produced by special wall roughness (riblets) and by flexible or heated walls.

The intention of the Symposium was to review recent research results from studies of turbulence structures in Newtonian as well as in non-Newtonian fluids and in particular from drag reduction studies which include details of the structure of the flow. Emphasis has been placed on the available knowledge about coherent structures to improve the understanding of drag reduction.

This review process provided at the same time an opportunity for analyzing the quality and completeness of available results on coherent structures. Such a critical analysis helped to define the fundamental questions more precisely, thus stimulating further progress in the field of coherent structures and drag reduction.

At a IUTAM Symposium on drag reduction held at the University of Essen in 1984 attention was restricted to polymer additives and mainly to the influence of their physico-chemical parameters (molecular structure, molecular weight, molecular weight distribution) as well as rheological aspects, such as the elongational viscosity. This emphasis reflected the current research interests at this time. However, even at the Symposium in Essen it was suggested that aspects excluded due to the limited available time, such as the influence of turbulence structures (in particular coherent structures) and the multiplicity of other additives, should be the subject of a meeting in the future .

A thematical structure was provided to the large topic of the Symposium by nine invited lectures which reviewed the various aspects of coherent structures, rheological properties of the additives, the different drag reducing effects and aspects of the stability of a turbulent flow. These state of the art reviews were supplemented by 23 orally presented contributions and 20 papers presented as posters. Fortunately practically all contributions could be accepted for publication in the proceedings. This is mainly the merit of the members of the scientific committee and some external reviewers who preselected the contributions from about a hundred based on the submitted abstracts.

The achieved scientific progress can be summarized as follows:
- Mainly it became evident that drag reducing effects are caused more by specific interactions of all size of structures rather than by an interaction of only selective parts of the turbulence spectrum.
- The models explaining drag reduction are still controversal. The main contribution of the Symposium therefore seems to be the idea that drag reduction should not be discussed only in terms of supressing mechanisms but also in terms of topological explanations based on specific anisotropies of the turbulent flow field, e.g. high helicity.
- Drag reduction by riblets have a lot in common with drag reduction by additives and should be describable in similar terms.
- The audience was very sceptic whether drag reduction by LEBUs exists or not.

Last but not least I would like to thank the members of the Scientific Committee who at all stages during the preparation of the conference, maintained a very close rapport. In addition to the members of the Scientific Committee we would like to thank especially Prof. T.Dracos and Drs. J. Bühler, A. Müller and X. Studerus (ETHZ), Dr H.-W. Bewersdorff (Univ. of Dortmund) and Prof. A. Tsinober (Tel Aviv Univ.). Thanks are also given to D.Fruman and B. Gampert and his wife for their contributions which were not part of the official program. Thanks go also to my wife Edith who organized the ladies program and to my two daughters Nadia and Regina for their help in the organisation work.

The ready and efficient cooperation of Herr von Hagen and the editorial staff of Springer Verlag during the preparation for the printing of the Proceedings is specially acknowledged.

It is our hope that this book will stimulate further research efforts in this exciting field of fluid mechanics.

Zürich, November 1989 Albert Gyr

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Final Program

SECOND IUTAM SYMPOSIUM ON STRUCTURE OF TURBULENCE AND DRAG REDUCTION

FEDERAL INSTITUTE OF TECHNOLOGY, (ETHZ) ZUERICH SWITZERLAND
25th to 28th JULY 1989

Tuesday July 25, 1989

Opening Address

STRUCTURE OF TURBULENCE

Session 1 (Chairman: R.F. Blackwelder)

S.J. Kline & S.K. Robinson
(Stanford University, NASA-Ames Res. Cent., USA)
Review: given in two parts.

S.J. Kline: Turbulent boundary layer structures: Progress, status, and challenges.

S.K. Robinson: A review of vortex structures and associated coherent motions in turbulent boundary layers.

C.R. Smith, J.D.A. Walker, A.H. Haidari & B.K. Taylor (Lehigh Univ., USA). Hairpin vortices in turbulent boundary layers: The implications for reducing surface drag.

M. Gad-el-Hak (Univ. Notre Dame, USA) Flow control by suction.

D.E. Nikitopoulos (LSU Baton Rouge,USA) & J.T.C. Liu (Brown University, USA) Non-linear coherent mode interactions and the control of shear layers.

Session 2 (Chairman: T. Maxworthy)

J.D.A. Walker (Lehigh Univ., USA) Modes of wall-layer eruptions in turbulent flows.

R.E. Falco, J.C. Klewicki & K. Pan (MSU East Lansing, USA) Production of turbulence in boundary layers and potentials for modification of the near wall region.

R.A. Antonia (Univ. Newcastle, Australia), R. Dumas & L. Fulachier (Univ. d'Aix-Marseille, France) Visualisation of the organized motion in a turbulent boundary layer.

T.R. Anderson (Dept Navy NUWSC, USA) Wavenumber-frequency spectral densities of turbulent wall pressure and wall shear fluctuations.

Session 3 (Chairmans: I.J. Wygnanski & T. Dracos)

Poster A discussion

(1) R.S. Azad & B. Doell (Univ. of Manitoba, Canada) Behaviour of separation bubble with different roughnes elements at the leading edge of a flat plate.

(2) J. Meyer, A. Sevrain, H.C. Boisson & H. Ha. Minh (IMFT Toulouse, France) Organized structures and transition in the near field of a plane jet.

(3) O. Inoue (Tohoku Univ., Japan) Artificial control of turbulent mixing layers.

(4) A. Müller (ETHZ, Switzerland) Quadrant analysis and instantaneous momentum transport - a critical review.

(5) H.T. Loesser (USA) Analysis of experimental data on boundary layer pressure fluctuations in turbulent pipe flow.

1. Panel Discussion "Coherent structures in turbulence"
Conductors: C.M. Ho, R.E. Falco & C.R. Smith

Wednesday July 26, 1989

DRAG REDUCTION BY DILUTE POLYMER SOLUTIONS & INHOMOGENEOUS INJECTION OF CONCENTRATED SOLUTIONS.

Session 4 (Chairman: M.M. Reischman)

L.G. Leal (CALTEC, USA) The review was given by S. Banerjee UCSB, USA)
Review: The rheological behavior of dilute polymer solutions

W.G. Tiederman (Purdue Univ., USA)
Review: The effect of dilute polymer solutions on the viscous drag and turbulence structure.

P.S. Virk (MIT, USA) Aspects of mechanisms in type B drag reduction.

A. Gyr (ETHZ, Switzerland) & H.-W. Bewersdorff (Univ. Dortmund,F.R.G.) Changes of structures close to the wall of a turbulent flow in drag reducing fluids.

B. Gampert & C.K.Yong (Univ. of Essen, FRG) Influence of polymer additives on the coherent structures of turbulent channel flow.

R.H. Nandolink (NUWSC, Newport,USA) Interaction of molecules and turbulent flow in dilute polystyrene solutions.

Session 5 (Chairman: P.S. Virk)

H. Usui (Yamaguchi Univ., Japan)
Review: Drag reduction caused by the injection of a polymer solution into a pipe flow.

N.S. Berman (ASU Tempe, USA) Large eddies and polymer strings.

V.N. Mamonov, B.P. Mironov & S.V. Panov (USSR Acad. Sc., Novosibirsk,USSR)
Drag reduction at injection of polyethyleneoxide solution into turbulent boundary layer through perforated section or a slot.

Session 6 (Chairmans: C. Elata & R.H. Nadolink)

Poster B discussion

(1) H. Mizunuma, H. Kato & T. Kurita (Tokyo Metrop. University, Japan)
Λ - shaped vortices in dilute polymer solutions.

(2) AN.A. Borisov, B.P. Mironov, B.G. Novokov & V.D. Fedosenko
(ITP USSR Akad. Sc., Novosibirsk, USSR) Wake flows in dilute polymer solutions.

(3) H.C. Hou (Guangdong Res. Inst., Guangzhou, China)
Hydrodynamic stability of laminar sublayer and drag reduction.

2. Panel Discussion "Drag reduction by dilute and heterogeneous polymer solutions"
Conductors: B. Gampert, W.G. Tiederman & M.M. Reischman

Thursday July 27, 1989

DRAG REDUCTION BY OTHER MEANS

Session 7 (Chairman: D.H. Fruman)

H.-W. Bewersdorff (University of Dortmund, FRG)
Review: Drag reduction in surfactant solutions.

K. Abe, A. Matsumoto, H. Munakata (Nihon Univ.) & I. Tani (NAL, Japan)
Drag reduction by sand grain roughness.

M. Krol (Univ. Kaiserslautern, FRG) Inertial interaction of spherical and fibre like solid particles with turbulent flowing liquids.

H. Gustavsson (Lulea Univ. of Techn., Sweden) The effect of three-dimensional surface elements on boundary layer flow.

Session 8 (Chairman: S.K. Robinson)

A. Tsinober (Tel-Aviv University, Israel)
Review: Turbulent drag reduction versus structure of turbulence.

COMPUTATION AND STABILITY

M. Landahl (MIT, Cambridge Mass., USA)
Review: Hydrodynamic instability and coherent structure in turbulence.

S.L. Lyons, T.J. Hanratty (Uni. ILL Urbana) & J.B. McLaughlin (Clarkson Uni. NY.) Relation of turbulence production to eddy structure in wall turbulence

J. Kim & P. Moin (NASA Ames Res.Cent., Moffet Field California,USA) Active turbulence control in a wall-bounded flow using direct numerical simulations.

Session 10 (Chairmans: N.S. Berman & R.H. Nandolink)

Poster C discussion

(1) C. Vossmerb‰umer & G. Schweiger (Univ. Duisburg, FRG)
Determination of regular structures in turbulent mixing processes.

(2) F. Anselmet*, R.A. Antonia (Univ. Newcastle, NSW, Australia), T. Benabid* & L. Fulachier* (*Univ. Aix-Marseille, France)
Effect of wall suction on the transport of a scalar by coherent structures in a turbulent boundary layer.

(3) J. Deville, J.P. Bonnet (CEAT/CNRS, Poitiers, France) & J. Lemay (Univ. Laval, Quebec, Canada)
Analysis of the wake of an outer layer manipulator.

3. Panel Discussion "Drag reduction by surfactants implication of stability, computation of turbulence making use of the concept of coherent structures"
Conductors: N.S. Berman, J. Kim & J.L. Zakin

Friday July 28, 1989

DRAG REDUCTION BY PASSIVE MEANS

Session 11 (Chairman: I.L. Ryhming)

A.M. Savill (University of Cambridge, England)
Review: Drag reduction by passive devices - a review of some recent developments.

C.E. Wark & H.M. Nagib (IIT, Chicago, USA) Relation between outer structures and wall-layer events in boundary layers with and without manipulation.

J.B. Anders (NASA Langley Res. Cent., Hampton, VA, USA) Boundary layer manipulators at high Reynolds numbers.

Session 12 (Chairman: M. Gad-el-Hak)

R. Friedrich & H. Klein (TUM, M‚nchen, FRG) Large scale turbulence structures in a manipulated channel flow.

R.F. Blackwelder (USC, Los Angeles, USA) The effects of longitudinal roughness elements and local suction upon the turbulent boundary layer.