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Engineering Turbulence Modelling and Experiments

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Proceedings of the International Symposium on Engineering
Turbulence Modelling and Measurements held September 24–28, 1990
in Dubrovnik, Yugoslavia

Editors

W. Rodi

Institut für Hydromechanik
Universität Karlsruhe
Karlsruhe, F.R. Germany

E.N. Ganić

Faculty of Mechanical Engineering
University of Sarajevo
Sarajevo, Yugoslavia



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PREFACE

The International Symposium on the Application of Electromagnetic Forces (ISEM) was held from January 28 to 30, 1991 at the Sendai Kokusai Hotel, Sendai, Japan. The conference was hosted by the Institute of Fluid Science, Tohoku University. The chairman was Junji Tani, and the general secretary Toshiyuki Takagi.

This was the third ISEM symposium. The first was organized in Tokyo in 1988, chaired by K. Miya (the University of Tokyo) and the second in Kanazawa in 1990, chaired by K. Bessho (Kanazawa University). The next symposium in this series will be held in January 1992 in Nagoya, to be chaired by Y. Uchikawa (Nagoya University).

The primary aim of the event was to seek a better understanding of electromagnetic phenomena and their applications, and to provide an international forum for debate on their role at the present time and for the future. The symposium was attended by 318 distinguished scientists and included 59 from abroad (15 countries). The scope of the conference was divided into 12 different sessions devoted to chosen, important subjects of electromagnetic force applications (organizers in parentheses): piezoelectric actuators (K. Uchino, Sophia University), nondestructive testing (T. Takagi, Tohoku University), microactuators (M. Esashi, Tohoku University), superconductivity (J. Tani, Tohoku University), magnetic damping (K. Nagaya, Gunma University), magnetic fluids (T. Tanahashi, Keio University), melted steel (R. Yamane, Tokyo Institute of Technology), electromagnetic materials (E. Matsumoto, Kyoto University), magnetic bearings (Y. Okada, Ibaraki University), computational electromagnetics (T. Honma, Hokkaido University), magnetic levitation (K. Yoshida, Kyushu University), and wave propagation (Y. Shindo, Tohoku University). To uphold the high scientific level of each session, some outstanding experts in every field were invited to deliver an oral presentation. Every contributed paper was presented at one of three poster sessions held afternoons. Thirty-five papers were presented in oral form, whereas the number of poster papers was 137. The total number of authors presenting their work was 360. The special opening lecture "Power electronics and microfabrication" was delivered by J. Nishizawa, President of Tohoku University.

Phenomena connected with the application of electromagnetic forces play an important role in technology, and stimulate the industrial progress of the world. A short resume of the various problems treated at the symposium is presented below.

The first session about *piezoelectric actuators* focused on high strain actuators, which can give large electrically controlled strains up to 1%. Data on switching

speed, state stability, and aging behavior were also presented. Results on piezoelectric actuators for micro motion control were reported as well. It is worth while to mention the new precise positioning mechanism with applications spread in various fields. Photostrictive actuators which start operating after receiving the energy of light, and which are suitable for use in photo-driving micromechanisms, were also included in the scope of this session. The second session on *nondestructive testing* presented methods using electromagnetic phenomena for testing composite materials as well as the procedure of detecting and evaluation of geometrical defects included in metal structures. This subject has an important application possibility in nuclear power plants, aircraft, railway vehicles, ships, etc. The *microactuator session* was devoted to the study of micromechanical applications of forces. Micromachining based on the photofabrication technique was applied to the fabrication of micro electromechanical devices such as electrostatic micro motors, gears, and turbines (polysilicon substrate). The application of microrobots was mentioned. A review of several types of linear and rotary electrostatic micromotors and present design techniques was also presented. The next session entitled *application of superconductivity* was composed of three main subjects: superconducting linear drives at low temperature applied to superspeed Maglev transport, levitation forces between superconducting specimens of some ceramics at a low temperature (experimental treatment), and designing of superconductive actuators of the centimeter size. In the session on *magnetic fluids* papers were presented on the use of magnetic fields on gas-liquid two phase pipe flow of magnetic fluid to accelerate the flow speed, on phase transition in colloids of magnetic type, and on the use of HGMS technique to remove large particles from magnetic dispersions to increase a long time stability of magnetic fluids. Applications such as multistage magnetic fluids seals, and the transportation of magnetic fluids by rotating were also included in the session. The next session about *electromagnetic materials* gave participants insight into some applications of strong magnetic fields to materials science, the last theoretical developments in electromechanical fracture of piezo-electric ceramics as well as magnetomechanical fracture of ferromagnets, and also a model of a large magnetostrictive transducer capable of applying very large mechanical stresses. Most of the papers in the *magnetic bearings* session were related to stability problems, however, two papers discussed the possibility of a superconductive bearing, which could support the shaft without control. An historical review and last results on the subject were included in the session. The fundamental ideas of construction, control and applications of the magnetic bearings were summarized. Also treated were: design of low power-loss magnetic bearings using permanent magnets, unbalanced force compensation, and a high level digital control scheme, as well as induction type repulsive bearings and motor capability. The next session was devoted to *computational aspects of electromagnetism*. The methods and software for advanced electromagnetic field computation from DC to daylight were presented and based on magnetic vector potential. The present status of 3-D numerical analysis of magnetic fields was summarized and various methods for this purpose were reported briefly. An alternative method of computation of electric and magnetic fields and forces in design of power apparatus was also presented. A session on *magnetic levitation* was also part

of the symposium. Controlled and inherently stable modes of magnetic levitation for vehicle suspension were treated as well as electromagnetic levitation of elastic plates. Some interesting and modern treatments about underwater linear motor cars were presented. The chaotic behavior of the magnetically levitated mass model showing strange attractors and bifurcations was reported. In the session devoted to *wave propagation* the anti-plane and plane-strain wave motions in piezoelectric layered media were considered. Surface waves in functionally gradient piezoelectric materials were reported as well, and a resume of GHz-range unidirectional surface acoustic wave transducers and low pass filters was made. An interesting method for calculating the deflection and eddy currents in conductors in the time varying electromagnetic field was reported. Some electromagnetic interactions in the deformable solids continua were studied by a group of authors and presented in the poster session. The last two sessions appeared mostly in poster form (one invited lecture for each). The session about *magnetic dampers and mechanical systems* presented the detail and critical current densities of superconducting oxides and magnetic levitation in a cylindrical superconductor with a video demonstration of the experiment. The vibration damping control of a stepping motor by a magnetic horde damper and a rapid control system consisting of a magnetic coupling and a stepping motor were reported. There were also reports on the active dynamic absorber with electromagnetic forces and its vibration control effects. Some fundamental research, which would be useful to analyse mechanical systems were discussed as well, such as mechanical and magnetic bodies with cuts (crack propagation effects) and mathematical models of induction heating of pipes. The session entitled *magnetic control of melted steel* focused on electromagnetic processing of materials, as it is one of the most advanced technologies in the metallurgy and manufacturing of steel and new materials. Control of the flow and the shape of liquid metal by one of three types: DC, AC, and high frequency AC magnetic field was proposed and discussed. Combined problems of fluid dynamics and electromagnetics were included in almost every paper of this session.

Most of the papers presented at the Symposium were original, but some were reviews that contained valuable background to the problems discussed. This proceedings of the Third ISEM Symposium published as a supplement to volume 2 of the International Journal of Applied Electromagnetics in Materials contains 130 contributed papers after the review process, some papers after revision. Selected extended papers will be published in two special issues of this journal: Vol. 2, No. 3 and No. 4.

The growing number of participants during past ISEM meetings shows the necessity for a symposium on these topics. The next symposium in the ISEM series will be held in Nagoya from January 26 to 29, 1992 and will focus on nonlinear phenomena in electromagnetic fields.

Our sincere gratitude is expressed to the principal sponsors, namely the Ministry of Education, Science and Culture, Miyagi Prefectural Government, Sendai Municipal Government, Inoue Foundation for Science and a number of companies, which made this symposium possible. Special thanks go to the

Sendai Convention Bureau for the many suggestions and help in organizing the Symposium. Finally, the speakers, chairmen, Steering- and Organizing Committee members, and Session Organizers are gratefully acknowledged.

Junji Tani
Toshiyuki Takagi

PREFACE

These proceedings contain a collection of papers presented at the International Symposium on Engineering Turbulence Modelling and Measurements held at Dubrovnik, Yugoslavia, in the period September 24–28, 1990.

Turbulence plays an important role in practically all engineering problems involving fluid flow. Turbulent motions have a determining influence on the distribution of velocity, temperature and species concentration over the flow field and consequently on the forces exerted by the flow, the mixing, dilution and heat and mass transfer. Seldom can turbulence be controlled directly, but in their designs engineers still need to optimise its beneficial effects and minimise its detrimental ones. To this end, turbulence and its consequences must be understood and also predictable. An optimisation of the fluid mechanics design is all the more important as engineering apparatuses become more and more complex and their performance is pushed to the limits. For the understanding of turbulence phenomena, experiments are indispensable, but they are also essential for providing data for the development and testing of prediction methods. In the latter, the most difficult aspect is the modelling of the turbulence effects, that is a realistic simulation of turbulent momentum, heat and mass transfer.

Recent years have seen great advances in the calculation of practically relevant turbulent flows, mainly due to the increase in computer power which allowed the development and use of more and more complex simulation techniques for turbulence. But also the techniques for measuring turbulent flows have undergone revolutionary changes so that many new experimental studies could be carried out and new phenomena could be detected. The symposium provided a forum for presenting and discussing this recent work in the area of modelling and measurements of turbulent flow. The invited and contributed papers included in these proceedings cover the developments in this field for a wide range of engineering problems and were conveniently grouped into the following sections:

- Turbulence modelling
- Turbulence model applications and comparison with experiments
- Direct and large-eddy simulations
- Experimental techniques
- Experimental studies

- Aerodynamic flows
- Flows in turbomachinery
- Combustion systems
- Heat and mass transfer
- Two-phase flows

The conference was organised under the auspices of the Assembly of World Conferences on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics. The sponsorship of the following professional societies and institutions is also acknowledged:

- Universität Karlsruhe, F.R. Germany
- European Centre for Peace and Development
- Yugoslav Federation of Engineers and Technicians
- Inter-University Centre, Dubrovnik, Yugoslavia
- International Journal "Experimental Thermal and Fluids Science"

We are grateful to the members of the Scientific and Organising Committee for their various efforts in making this conference a success. We also acknowledge the help of the many fluid mechanics experts from all over the world in reviewing abstracts and full papers for the conference. Finally, we express our sincere appreciation for the cooperation provided by Messrs. R.K. Shah, President of the Assembly of World Conferences on Experimental Heat Transfer, Fluid Mechanics and Thermodynamics, Paul Weislogel, Ed Connor and Greg Giblin of Elsevier Science Publishing Company in the preparation of the proceedings.

W. Rodi and E.N. Ganić

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