Vibration and Oscillation of Hydraulic Machinery

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Vibration and Oscillation of Hydraulic Machinery

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Preface

The publishing of this book series on Hydraulic Machinery, organised and edited by the International Editorial Committee for Book Series on Hydraulic Machinery (IECBSHM), marks the results of successful cooperation between the Committee, the authors and the editors of each volume.

The Editorial Committee consists of 35 scholars from 20 countries. More than 100 academics and engineers from 23 countries have participated in the compilation of the book series. The volumes reflect the latest developments, gained from many countries, in concepts, techniques, and experiences related to specific areas of hydraulic machinery. This is a great joint exercise by so many experts on a world wide basis that will inevitably bring impetus to technical achievement and progress within the hydraulic machinery industry and promote understanding and cooperation among scholars and professional societies throughout the world.

The authors have devoted considerable time and energy to complete the manuscripts and even more time was occupied by the editors in revising and correlating the individual volumes. Dr A P Boldy, Secretary IECBSHM, contributed greatly to the overall editing and preparation of the final manuscripts. Mr J G R Hindley, of Avebury Technical, offered many suggestions and remained helpful in every phase of the editorial and publishing work.

Great assistance in the preparation of the manuscripts from numerous persons in different parts of the world have been received, without which the publication of the book series would not have been possible. I would like to express appreciation both from myself and on behalf of the Editorial Committee to these people, the list of names being too lengthy to include here.

Duan Chang Guo
Chairman IECBSHM

Foreword of the Editor

The present book *Vibration and Oscillation of Hydraulic Machinery* is a volume in the Book Series on Hydraulic Machinery organized by the International Editorial Committee. It deals with the vibration and oscillation problems which are hazardous to the safety and reliable operation of hydraulic machinery. It restricts its scope, however, to the problems which are caused by a mechanical or hydraulic excitation induced by the rotating machine itself or by a self-exciting mechanisms inherent in a specific flow pattern in the machine. It excludes, therefore, so-called transient phenomena from the scope, where the interaction between the piping and the machine plays the predominant role. These phenomena are treated in the volume on hydraulic transients of this Book Series.

Hydraulic machinery, or pumps and hydraulic turbines to be concrete, is the machine which converts shaft power to hydraulic energy or vice versa. The conversion is done in the rotating impellers of pumps or in the runners of hydraulic turbines and the hydrodynamic force on the vanes of impellers or runners is the direct medium of the energy conversion. The effectiveness of this conversion process, i.e. efficiency, must be as high as possible and the hydrodynamic design of impellers or runners together with their surrounding stationary parts is the most important part of the whole design procedures.

Hydraulic machinery with an excellent hydrodynamic performance occasionally experiences a vibration or oscillation problem, which results in the fracture of a specific machine element or forces to shut down the operation. If such situation happens, the machine cannot continue the operation. To assure hydraulic machinery of vibration-free smooth operation is therefore as vital as to materialize a good hydrodynamic performance.

Many of vibration and oscillation troubles of hydraulic machinery are found or detected after the machine was constructed and started its operation at the site. This makes the situation quite unfavorable because the search for the true cause of the trouble is difficult due to limited possibility of measurement at the site and also because the choice of remedies applicable to the machine after the installation is quite restricted. If once such trouble happens, the damages are quite severe both for suppliers and users through the loss of operation and the cost of man power and additional reconstruction works at the site. Utmost precautions must be paid therefore to prevent vibration and oscillation troubles especially at off-design operating condition where most of unexpected vibration events take place.

The present volume consists of nine chapters: Chapter 1 and chapter 2 describe fundamental concepts and methods of modelling and mathematical analysis of vibration phenomena. Chapter 3 and chapter 4 are on the vibration of structure due to mechanical and hydraulic excitations of rotating machinery. Chapter 5 deals with the vibration of rotating shaft system, i.e. rotordynamics aspects. In chapter 5 the stability of the flow in the machine and examples of self-exciting mechanism of the fluid system are described. Chapter 7 deals with the noise problem, that is, generation, transmission and control of noise. The last chapter 8 summarizes the diagnosis and remedy of vibration problems.

The coordinator is responsible for the grand design and composition of the contents of this book. Each chapter was written by a single author or by a group of authors, totaling eleven authors from nine countries. The authors are all experts of global fame in the specific fields. The authors are in nature prone to select materials which they are most interested in and they have experienced often in the practice. Consequently some items, for example vibration caused by vortex core formation in the draft tube of Francis turbines, are referred to in plural chapters of this Volume. The coordinator has overlooked these duplications deliberately, since different authors describe the same phenomena in different ways and such duplication could help readers understand the phenomena better and from various view points.

The recent development of technology has been accelerated by the use of electronic computers to a great extent. The vibration analysis of large structures and the computation of fluid flow are the very fields which have been and are enjoying the powerful assistance of computers. This situation necessarily requires more mathematical modeling and expressions for the numerical analysis and simulation of the phenomena. The reader will find in the text rather heavy mathematical expressions, in many cases in matrix form, which are indispensable for computational purposes. In the era of computers the importance of mathematical modeling is steadily increasing even for an engineer in practice. The coordinator hope that the readers would appreciate these equations and formulations when they encounter the demands which require a quantitative prediction beyond a qualitative one.

None of the authors including the coordinator of this Volume is native English speaker. Though we are deeply obliged to Dr A P Boldy of the University of Warwick, UK, for his careful reading and polishing of the text, there remain still a lot of 'English as foreign language' in the book. We would like to ask the readers the forbearance in this respect.

Each author submitted the manuscript in floppy disc to the coordinator, who converted the files by different word processors into the format of LaTeX system and prepared the camera-ready copy for the publication. Appreciation is due to Miss Miho Yoshie who helped the conversion including expression of complicated mathematical formulae.

Hideo Ohashi,
Coordinator

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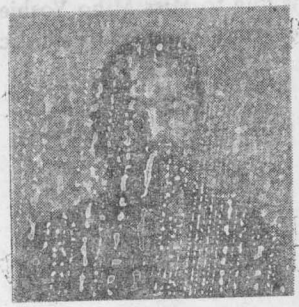

Born in 1931, male, Japanese. BS in 1954 at Univ. of Tokyo, Dr.-Ing. (T.H. Braunschweig) in 1958 and Dr. Eng. (Univ. of Tokyo) in 1963. 5 years experience in compressor design. Education and research at Univ. of Tokyo since 1959 on dynamic characteristics of turbopumps, fluid forces on vibrating centrifugal impellers, unsteady and two-phase flow in cascades and ventilation of vehicle tunnels.

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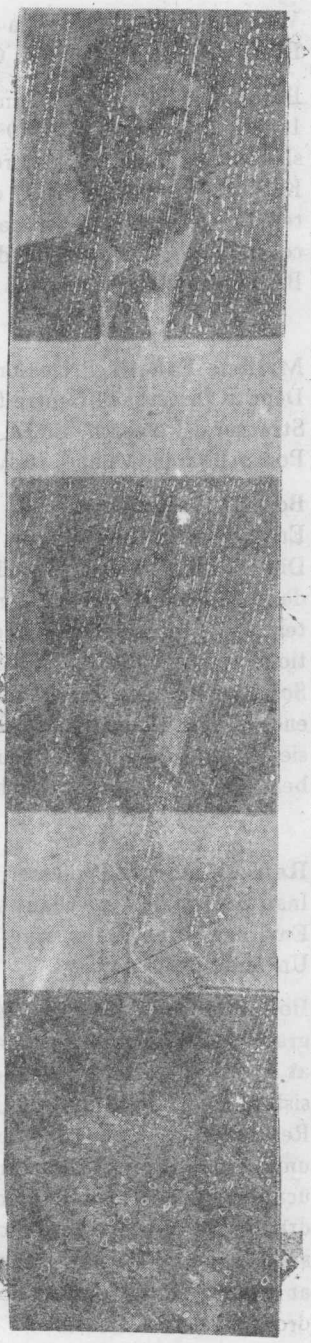

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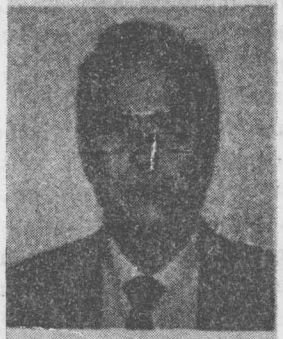
Born in 1958, male, German. Dipl.-Ing. in 1985 and Dr.-Ing. in 1989 at Univ. of Kaiserslautern. Education and research at Univ. of Kaiserslautern since 1985 on dynamic characteristics of turbopumps, machine dynamics and control theory. Since 1990 design department of BASF company for reactors and agitator vessels.



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Born in 1931, male, Italian. Degree in hydraulic Engineering in 1954 at Univ. of Bologna (Italy); Diploma Ingénieur Hydraulicien de l'Université de Grenoble in 1956 at Grenoble (France); free-teaching Professorship in technique of constructions at Rome, 1970. Employed first by Edison Society and then by ENEL. Extended experience in dam analysis and design, hydraulic transients, physical hydraulic modeling, instationary behaviour of hydraulic machinery and systems.

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Born in 1940 in Uruguay. Mechanical engineer, graduate of Univ. of Uruguay. Dr.-Ing. in 1988 at National University of Mexico (UNAM). Assistant Prof. at Univ. of Uruguay until 1973. Researcher at Univ. of Mexico until 1985 and until today IFMEE Director. Research and education since 1980 on dynamic behaviour of hydraulic machinery, hydraulic transients in pressure conduits, stability of swirl flow in Francis and Kaplan units, combustion chambers and hydrocyclones.

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Born in 1943, male, Japanese. Graduated from School of Engineering Teachers, Kyushu Univ. in 1965. Dr. Eng. (Kyushu Univ.) in 1976. Studies on fluid dynamics at Res. Inst. of Industrial Sci., Kyushu Univ. from 1965 to 1971. Education and research at Kyushu Inst. Tech since 1971 on fluid mechanics of internal flow, boundary layer control, diffuser performance, draft tube surging and flow measurement.

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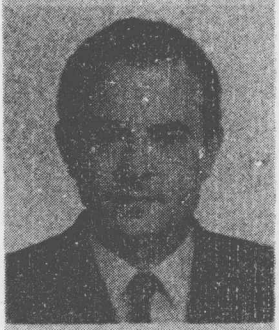

Born in Barcelona. Industrial Eng. and Dr. Eng. by the UPC. Assistant and Associate Prof. in 1977-83 at the Faculty of Industrial Eng. (ETSEI) in Terrassa. Prof. in 1983 at the Univ. of Oviedo. Prof. in 1988 at the ETSEI in Barcelona. Research on unsteady flows, flow induced vibrations and condition monitoring in turbomachinery (axial flow fans and hydraulic turbines). Researches also on molten metals.

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