



WATER POWER ENGINEERING

SECOND EDITION



M M Dandekar
K N Sharma

WATER POWER
ENGINEERING

WATER POWER ENGINEERING

Second Edition

M M DANDEKAR

Ex-Professor

Malaviya Regional Engineering College, Jaipur

K N SHARMA

Consultant, Water Resources and Hydro-power

Formerly

Secretary, International Commission on Irrigation and Drainage

New Delhi

and

Asstt Professor

Malaviya Regional Engineering College, Jaipur



VIKAS® PUBLISHING HOUSE PVT LTD



VIKAS® PUBLISHING HOUSE PVT LTD

E-28, Sector-8, **Noida**-201301 (UP) India

Phone: +91-120-4078900 • Fax: +91-120-4078999

Registered Office: 576, Masjid Road, Jangpura, **New Delhi**-110014. India

E-mail: helpline@vikaspublishing.com • Website: www.vikaspublishing.com

- **Ahmedabad** : 305, Grand Monarch, 100 ft Shyamal Road, Near Seema Hall, Ahmedabad-380 051 • Ph. 079-65254204, 98982 94208
- **Bengaluru** : First Floor, N.S. Bhawan, 4th Cross, 4th Main, Gandhi Nagar, Bengaluru-560009 • Ph. +91-80-22204639, 22281254
- **Chennai** : E-12, Nelson Chambers, 115, Nelson Manickam Road, Aminjikarai Chennai -600029 • Ph. +91-44-23744547, 23746090
- **Kolkata** : P-51/1, CIT Road, Scheme-52, Kolkata-700014 • Ph. +91-33-22866995/6
- **Mumbai** : 67/68, 3rd Floor, Aditya Industrial Estate, Chincholi Bunder, Behind Balaji International School & Evershine Mall, Malad (West), Mumbai-400064 • Ph. +91-22-28772545, 28768301
- **Patna** : Flat No. 204, Temple Tower, Sabjibagh, Birla Mandir Road, Patna-800004 • Ph. 94310 15579

Distributors:

UBS PUBLISHERS' DISTRIBUTORS PVT LTD

5, Ansari Road, **New Delhi**-110002. India

Phone: +91-11-23273601, 23266646 • Fax: +91-11-23276593, 23274261

E-mail: ubspd@ubspd.com • Website: www.gobookshopping.com

- **Ahmedabad**: +91-79-22160371 / 2 / 3 • **Bengaluru**: +91-80-26756672 / 3
- **Bhopal**: +91-755-4203183 / 93 • **Bhubaneswar**: +91-674-2314446
- **Chennai**: +91-44-23746222, 23746351 / 2 • **Coimbatore** : +91-422-2499917
- **Ernakulam**: +91-484-2353901, 2373901, 2363905 • **Guwahati** : +91-361-2461982 / 3 / 4
- **Hyderabad** : +91-40-24754472 / 3 • **Kolkata**: +91-33-22529473, 22522910
- **Lucknow**: +91-522-4025124 / 34 • **Mumbai**: +91-22-66376922 / 3, 66102069
- **Nagpur**: +91-712-2736010 / 1 • **Patna**: +91-612-2672856, 2673973
- **Pune**: +91-20-24461653, 24433976

Water Power Engineering

ISBN: 978-93259-6898-1

First Published 1979

Reprinted several times

Second Edition 2013

Vikas® is the registered trademark of Vikas Publishing House Pvt Ltd

Copyright © Authors, 1979, 2013

All rights reserved. No part of this publication which is material protected by this copyright notice may be reproduced or transmitted or utilized or stored in any form or by any means now known or hereinafter invented, electronic, digital or mechanical, including photocopying, scanning, recording or by any information storage or retrieval system, without prior written permission from the publisher.

Information contained in this book has been published by VIKAS® Publishing House Pvt Ltd and has been obtained by its Authors from sources believed to be reliable and are correct to the best of their knowledge. However, the Publisher and its Authors shall in no event be liable for any errors, omissions or damages arising out of use of this information and specifically disclaim any implied warranties or merchantability or fitness for any particular use. Disputes if any are subject to Delhi Jurisdiction only.

Printed in India.

Dedicated to the memory of

Late Prof M M Dandekar

*who was a perfect human being and
an epitome of knowledge and human virtues*

KAMLA NATH SHARMA



Acknowledgements

The authors are grateful to the following organizations/individuals and acknowledge the use of some material from their publications or pictures graciously provided by them:

Messrs ABB Ltd., Switzerland;	Alexander M. Gorlov;
Alstom, France;	Andritz Hydro, Austria;
Atlas Copco, Sweden;	AWS Ocean Energy, Scotland;
CKD Blansko, Czech Republic;	Energetech Australia Pty.Ltd.;
F. Lempérière, Hydrocoop, France;	Swedish State Power Board;
THDC India Ltd.;	VAP Hydro, Bulgaria;
VA Tech Hydro, Austria;	Vortex Hydra, Italy (info@vortexhydra.com);
Voith Hydro Holding GmbH & Co. KG, Germany;	
Water Power and Dam Construction Co., London (A. Ait Alla, Hydro Plus, Fuse gate);	
Hungarian Academy of Sciences, Budapest, for permitting to use material from their publication 'Water Power Development' Vols. I and II by E. Mosonyi.	



Preface to the Second Edition

I am glad to bring out this revised and enlarged edition of Water Power Engineering text and reference book.

Since the publication of the first edition more than three decades ago, the hydro-power sector has seen several developments. Small-scale hydro-power attracted attention and started its contribution to meet the challenge of power deficit. With the activists becoming even more vociferous the environmental issues got prominence in various discussions globally that enabled the planners and decision makers to formulate guidelines for scrutiny of hydro-power projects for environmental and forest clearance, including rehabilitation and resettlement of project-affected people. The revised edition of the book therefore has two additional chapters—one on small-scale hydro projects and the other on environmental impact of water resources projects.

Although the need for revision of the book had been felt long time back, due to various circumstances it could not be done. Unfortunately, Prof. MM Dandekar, the main spirit behind the book, who was guiding the revision work passed away in 2002. However, his memory which is always inspirational, as also the constant enquiries from readers all over the world, proved to be the driving force in completion of this revised, updated and enlarged edition.

All the chapters have now been thoroughly revised and updated with latest information on the subject. Several relatively new developments, technologies and structures, for example stepped and piano key type spillways; fuse gates and fuse plugs for spillways; concrete faced rock-fill dams (CFRD), rock-filled concrete (RFC) dams and roller compacted concrete (RCC) dams; reverse flow throttling in surge tanks for pumped-storage plants; wave power generation devices like Archimedes wave swing, the pelamis, the wave dragon etc., have been added in the relevant chapters. Issues such as sedimentation in the dam-related storages affecting power generation, multiplier effect of dams, greenhouse gases from reservoirs, climate change and hydro-power, abrasion in hydraulic machines, etc., have also been discussed so as to cover the latest concerns in the field of hydel power.

It was suggested by some well-wishers that chapters on irrigation engineering be also added to the book. It is humbly submitted that it was considered prudent for the time being to maintain the exclusivity of the subject of water power engineering as was contemplated when the book was first written.

While seeking apology from the readers for the inordinate delay in the revision of the book, it is hoped that the updated information will be useful for the students as well as those interested in the subject. Suggestions for further improvement of the book will be highly welcomed from the discerning readers.

K N Sharma



Preface to the First Edition

This book is planned essentially as a textbook for the students interested in Water Power Engineering. This subject is a vast area of engineering, employing diverse disciplines and needs large handbook-type volumes in order to deal with all the aspects thoroughly. As a matter of fact, many such handbooks are already available. On the other hand, there is hardly any book that is suitable for the instructional use in the engineering faculty. While this has been our major motivation in writing this book, we have taken ample care to see that the field engineers active in this area would find the information content in this treatise of substantial use. The basic design principles have been carefully enunciated and the detailed design practices have been indicated. Subjects like hydrology, dam design, turbines and other mechanical and electrical equipments are vast subjects by themselves and to include the comprehensive design procedures is not even possible in a book of this kind.

To the extent possible, we have tried to include all the up-to-date information. Water Power Engineering has taken giant strides in the last twenty-five years and we have made a conscious effort to introduce to the reader all the modern concepts and practices. We have quoted a number of examples from hydro-projects all over the world to illustrate and emphasize the general principles. Methodology of calculation has been illustrated with solved examples.

Unlike a research document, a text book is basically a culled information from different sources. We gratefully acknowledge the debt of all the earlier contributors in this area. We have refrained from giving detailed references in the text and have only included a list of important references at the end of the book. We, however, would like to particularly mention here Dr. Emil Mosonyi's 'magnum opus' *Water Power Development* as also *Journal of Water Power and Dam Construction* as our two important sources of information.

It would be virtually impossible to mention the names of all the persons who have lent a helping hand in this project. We would, however, like to place on record our gratitude to Principal, Malaviya Regional Engineering College, Jaipur (India) for allowing us to take up this project; to University Grants Commission, India for sponsoring the project and for providing financial assistance in the form of a fellowship and to National Book Trust of India who have adopted this book for their subsidized textbook publishing programme.

We are particularly grateful to the editorial committee nominated by the UGC (India) and consisting of Dr. Jagdish Lal, Principal, MNR Engineering College, Allahabad, Dr. S. Narasimhan, Professor, IIT, Bombay, and Prof. M.A. Brahmankar of Walchand College of Engineering, Sangli, for going through the draft manuscript and for making valuable suggestions. Their effort and interest is sincerely appreciated.

Our thanks are also due to our colleagues and staff in our Department and in particular to Mr. D. Jagtani, who has provided an able secretarial assistance throughout this book-writing project.

Authors



Contents

Preface to the Second Edition ix

Preface to the First Edition x

1. Extracting Energy from Water 1–26

Global Energy Overview 1; Sources of Power and Renewables 6; Global View of Hydro-power Potential 9; Hydro-power: Indian Scenario and Prospects 11; Inter-regional Imbalances 15; Transmission of Power 17; SWOT of Hydro-power 20; Estimation of Hydro-potential 21; Place of Hydro in the Power Mix 22; Multi-purpose Development 22; Climate Change and Hydro-power 23; India's Cooperation with Neighbouring Countries 24; Questions 25

2. Elementary Hydrology 27–42

Definitions 27; Branches of Hydrology 27; Hydrologic Cycle 28; Hydrologic Equation 29; Infiltration 30; Evaporation 33; Streams and Stream Flow 36; Statistical Nature of Hydrology 37; Illustrative Examples 39; Questions 41

3. Precipitation 43–63

Occurrence and Causes of Precipitation 43; Measurement of Rainfall 44; Interpretation of Rain-gauge Data 51; Graphical Representation of Rainfall 53; Extreme Values of Precipitation 56; Precipitation Patterns in India 59; Illustrative Examples 60; Questions 63

4. Runoff and Stream Flow 64–107

Runoff Process 64; Stream Flow Analysis 65; Hydrograph 69; Mass Curve 70; Flow Duration Curve 71; Rainfall–Runoff Relation 72; Factors affecting Runoff 72; Estimation of the Runoff 74; Low Flow Analysis 82; Flood Runoff 83; Unit Hydrograph Method 88; Synthetic Unit Hydrograph 92; Illustrative Examples 95; Questions 106

- 5. Electrical Load on Hydro-turbines** **108–118**
Load Curve 108; Load Factor 110; Power Factor 110; Capacity Factor 111; Utilization Factor 112; Diversity Factor 112; Load Duration Curve 112; Firm Power 113; Secondary Power 114; Prediction of Load 114; Illustrative Examples 115; Questions 118
- 6. Low and High Head Plants** **119–173**
Classification of Plants 119; Run-of-river Plants 123; Valley Dam Plants 130; Diversion Canal Plants 134; High Head Diversion Plants 136; Storage and Pondage 138; Flow- and Power-duration Curves 143; Sedimentation of Reservoirs 144; Illustrative Examples 156; Questions 172
- 7. Pumped Storage Power Plants** **174–200**
Basic Features 174; Historical Development 176; Advantages of Pumped Storage Plants 178; Types of Pumped Storage Plants 179; Reversible Pump-turbines 183; Advantages/Disadvantages of Reversible Pump-turbines 188; Problems of Operation 191; Topography 193; Reservoirs and Water Conveyance 193; The Powerhouse 196; Efficiency of PS Plants 197; Illustrative Examples 198; Questions 200
- 8. Dams** **201–255**
History 201; Functions of a Dam 201; Classification of Dams 202; Selection of Site and Choice of Dams 203; Gravity Dams 205; Embankment Dams 217; Arch Dams 228; Buttress Dams 237; Roller-compacted Concrete (RCC) Dams 239; Concrete-faced Rockfill Dams 241; Rock-filled Concrete (RFC) Dams 244; Inflatable Dams 246; Failures and Safety of Dams 247; Rehabilitation of Dams 249; Multiplier Effect of Dams 249; Illustrative Examples 250; Questions 254
- 9. Spillways** **256–291**
Spillway Design Flood 256; Types of Spillways 257; Spillway Gates 274; Concrete Fuse Plugs 284; Dam Sluices 286; Energy Dissipation Below Spillways 286; Illustrative Examples 288; Questions 291
- 10. Penstocks and Accessories** **292–319**
Classification of Penstocks 292; Design Criteria for Penstocks 297; Economical Diameter of Penstocks 299; Anchor Blocks 303; Conduit Valves 307; Bends and Manifolds 316; Illustrative Examples 318; Questions 319

-
- 11. Water Hammer and Surges** **320–345**
Water Hammer 320; Resonance in Penstocks 328 Channel Surges 328; Surge Tanks 330; Illustrative Examples 341; Questions 345
- 12. Intakes, Canals and Tunnels** **346–384**
Intakes 346; Air Entrainment at Intakes 357; Canals 359; Tunnels 366; Questions 384
- 13. Turbines** **385–434**
Main Types of Turbines 385; Hydraulic Features 386; Turbine Size 392; Constructional Features of Turbines 392; Layout Arrangements 408; Hydraulics of Turbines 409; Velocity Triangles and Nomenclature 410; Basic Flow Equations 411; Draft Tubes 416; Cavitation in Turbines 418; Abrasion in Hydraulic Machinery 421; Governing of Turbines 422; Turbine Model Testing 426; Characteristics of Turbines 427; Illustrative Examples 428; Questions 434
- 14. Electrical and Mechanical Equipment** **435–452**
Generators 435; Transformers 442; Switchgear 443; Mechanical Equipment 446; Transmission of Electric Power 446; Questions 452
- 15. Planning of Powerhouses** **453–471**
Powerhouse Structure 453; History 461; Location of Underground Power Stations 462; Types of Underground Power Stations 463; Advantages of the Underground Powerhouse 464; Components of an Underground Powerhouse 466; Types of Layout 468; Limitations of an Underground Powerhouse 470; Structural Design of Powerhouses 470; Questions 471
- 16. Hydro-power From Oceans** **472–512**
Energy from Oceans 472; The Tidal Phenomenon 473; Basic Principles of Tidal Power 477; Historical Developments 478; Prominent Sites in the World and in India 479; Modes of Generation 482; Structural Components of Tidal Plants 486; Turbine Assembly and Generation 497; Power Output and Energy from Tidal Barrage 501; Economics of Tidal Power 503; Tidal Power Stations of the World 503; Environmental Effects 505; Illustrative Examples 511; Questions 512
- 17. Small-scale Hydro** **513–529**
Historical Development 514; Sites for Small-scale Hydro 515; Potential of Small-scale Hydro 516; Measures of Economy 517; Choice of Turbines 523; Prospects of Small-scale Hydro 528; Questions 529

18. Environmental Impact of Hydel and Multi-purpose Projects **530–540**

Hydel Projects 530; Data to be Collected/Monitored in a Water Project 536; Positive Impact of Water Projects 537; Possible Negative Impacts 538; Hydro-power and Greenhouse Gases 539; Environmental Laws in India 539; Questions 540

19. Some Typical Projects **541–582**

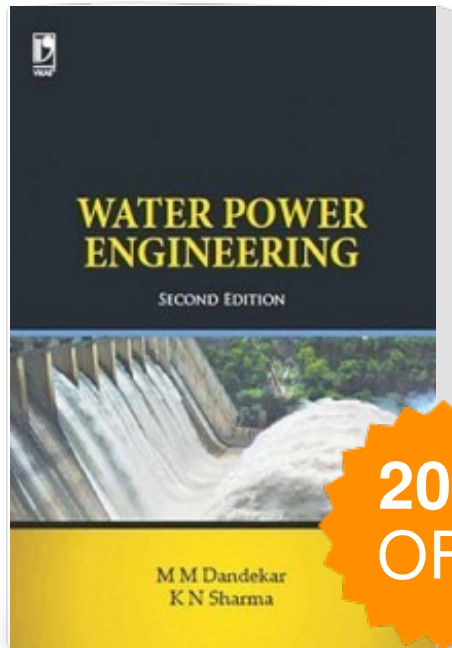
Beas Project 541; Tarbela Dam Project 545; Idukki Arch Dam Project 550; LA Rance Tidal Plant 552; Revin Pumped Storage Plant 555; Sardar Sarovar (Narmada) Project 557; Tehri Hydro-power Project 565

Appendices **583–596**

I. General Studies and Investigations Needed for Hydro-electric Projects	583
II. Recommended Values of Infiltration Loss Rates	586
III. World's Highest Dams	587
IV. World's Largest Dams	589
V. Largest Man-made Lakes / Reservoirs in the World	590
VI. Load Combinations for Gravity Dams	591
VII. Some Biggest Turbine Installations	592
VIII. World's Largest Hydro-power Plants	594
IX. Some Useful Units	596

Bibliography **597–602****Index** **603–610**

Water Power Engineering



Publisher : SChand Publications ISBN : 9789325968981

Author : M M Dandekar And
K N Sharma

Type the URL : <http://www.kopykitab.com/product/10367>



Get this eBook