

# Preface

Hydraulic turbomachines have played a prominent role in the procurement of renewable energy for more than a century. Embedded in the context of general technological progress, their design for efficiency and reliability has reached an outstanding level of quality, and no other turbomachines have reached the efficiency levels of Francis turbines, now close to 96 %. To maintain such a level in every project is a permanent engineering challenge because, unlike other types of equipment, the turbines and storage pumps for a hydroelectric power plant are usually ‘tailor-made’, that is their design is adapted to the flow and head available for a given location. Furthermore, with the fundamental changes in the electricity markets due to the integration of non-dispatchable renewables, such as wind and solar power, the role of hydropower in the electrical grid has dramatically changed from being a contributor of constant energy supply to a highly flexible supplier of ancillary services. Hydraulic turbomachines are nowadays operated in a far more dynamic way thereby requiring substantial progress in technology development.

The main hydraulic performance issues of hydroelectric machinery—output, efficiency, and cavitation—have been in the focus of interest right from the beginning because they are obviously linked with the owner’s financial success. Well-established practice and standards for testing these properties of the machines have existed for a long time. It is more difficult to assess in advance the durability of the equipment. Mechanical failure of one or more components after some period of operation is in most cases due to fatigue caused by fluctuating stress added to the steady-state load. These fluctuating stresses are, like the steady-state ones, a consequence of the working principle of the hydraulic machines. To predict them becomes more and more important if the machines should be designed for good hydraulic performance, but at the same time be developed for the lowest possible cost and the most flexible operation.

Apart from issues of mechanical safety, there are other reasons for limiting the unsteady phenomena. For example, spontaneous power swings due to some mechanism of instability are not acceptable for the electrical network. There are also some issues at the border between safety and convenience, phenomena like

pressure shocks, vibrations, and noise where both operators and suppliers may disagree about what is acceptable or not.

To make things even more challenging, the flexibility of modern power plants leads to a remarkable trend toward operating the equipment in off-design conditions for a larger percentage of time. As a consequence, the importance of fluctuating loads increases and the unsteady operational behavior must receive more attention.

The idea for this book was born a few years ago, when a number of researchers in the field, including one of the authors, reached the age of retirement. Engineers who have acquired specific knowledge in the field, both empirical and theoretical, owe a good deal of that knowledge to unforeseen technical mistakes and their correction. The problems that had to be dealt with typically occurred once in every few years, or even over many years. Within a well-governed company, however, such incidents drive a process of rule-making to provide guidelines to avoid similar events. Over the years, the body of rules and guidelines increases and the errors are finally avoided. It is not quite the same in the open literature of the technical community. Paradoxically, the very large number of conference papers seems to assist in the merciless erosion of know-how. In view of this we recognized that we should make this specific knowledge available in a more compact form, some of it being owed to publicly funded research projects, or collected in exchange of experience with colleagues from other companies in working groups organized by IAHR.

In addition, this book is intended as a contribution to help improving the efficiency of collaboration between the buyers and suppliers of hydroelectric machinery. We are faced in many projects with unrealistic or unpractical technical requirements with regard to unsteady performance. This is mainly due to lack of available information about the actual behavior of hydraulic machines. With our book, we want to close this gap of knowledge and contribute to a more rational handling of the subject in future projects.

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