Foreword by J.F. Booker

Hydrodynamic lubrication is a remarkably simple concept: solid surfaces separated by a thin fluid film, thus minimizing friction and wear.

By the last quarter of the 19th Century the concept had been validated experimentally by such engineers as Gustave-Adolphe Hirn (France), Beauchamp Tower (Britain), and Robert Thurston (United States).

Not long afterward, the British engineer and physicist, Osborne Reynolds, had derived the governing partial differential equation that bears his name. (The Reynolds equation is the 2-dimensional result of applying thin-film approximations to 3-dimensional Navier-Stokes and continuity equations.) By the very beginning of the 20th Century Reynolds himself and later the German physicist, Arnold Sommerfeld, had worked out many of the most obvious and simple steady-state solutions.

Why now, early in the 21st Century, do we need a new four-volume series entitled, “Hydrodynamic Lubrication”? The design methodology of the early 20th Century is still perfectly satisfactory for many bearings operating under steady conditions of low loads and speeds. However, the design analysis of many modern bearings must address unsteady response to dynamic loads, high temperatures, thin fluid films, surface finish limitations, structural compliance, and exotic inlet configurations (together with cavitating, piezoviscous, thermoviscous, highly non-Newtonian lubricant behavior), all in the effort to reduce power loss, wear, and cost.

Some of the most extreme demands have come from designs for internal combustion engines, which face continuous pressure for greater efficiency, lower weight, and higher power density.

In the second half of the 20th Century came gradual development of advanced design analysis techniques made possible by steady advances in computer resources and numerical methods.

Spatial discretization methods gradually came to include finite difference (FD), finite element (FE), and finite volume (FV) methods. Temporal integration techniques became more elaborate and more capable of dealing with such difficulties as “stiff” systems.

Lubrication problem categories progressed with increasing complexity (and lengthening acronyms) through hydrodynamic (HD), elastohydrodynamic (EHD), thermohydrodynamic (THD), and thermoelastohydrodynamic (TEHD).

While there is still a place in initial design studies and/or extended whole-engine system dynamic analyses for much faster (but much more approximate) methods, detailed design analysis now requires the powerful methods of numerical analysis developed by such specialists as the authors and previously reported in multiple research publications distributed widely over time and space.

An important set of these is now gathered together in one place in the form of an extended monograph — a distillation of some 25 years of work at the very forefront of the subject area carried out by the distinguished authors and others at the University of Poitiers in France. Though each chapter includes a bibliography appropriate for its subject matter, the book is not an extensive review of the work of others, except as it furthers the central development of the subject.

The previous two-volume series edition in French was largely inaccessible to Anglophones (such as myself). This new English edition should thus be welcomed by a much expanded audience. Division into a sequence of four smaller and more narrowly focused volumes seems a logical and convenient way to meet the needs of a diverse audience.

The first volume lays out in detail most of the necessary ingredients for modern design analyses of hydrodynamic bearings: lubricant rheology, fundamental equations of hydrodynamic lubrication and elasticity, and numerical solution techniques.

The second volume takes on the inter-related matters of surface finish, mixed lubrication, and wear.

The third volume extends modeling and solution techniques to include thermal effects.

The fourth volume addresses the specific challenges of hydrodynamic bearings in internal combustion engines, beginning with the kinematics and dynamics of the block-crankshaft-connecting rod-piston linkage, proceeding to detailed hydrodynamic lubrication analyses for each of the bearings in the chain, and culminating in a study of the application of formal experimental design to the bearing design optimization process. This approach allows the possibility of considering many more design variables and operating conditions than with conventional optimization techniques without overwhelming computing resources.

Professor Jean Frêne, also of the University of Poitiers, put it perfectly in his Foreword to the French edition:

> "The authors should be thanked and warmly congratulated for putting together in one comprehensive book their extensive knowledge on the complex topic of the mechanism of internal combustion engines and the lubrication of various highly loaded bearings operating under transient conditions."

It is an honor and a pleasure to second the motion.

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