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Noise of Polyphase Electric Motors

Preface

It has been estimated that over 65% of the electrical energy produced in the developed countries is consumed by electric motors. Electrical motors are the most popular machines of everyday life. They are used either as power machines providing propulsion torque or servo motors operating in a closed loop control with speed or position feedback. Electric motors are embeded in larger systems being their integral part. The noise radiated by electric motors affects immensely the overal noise of the system.

Contemporary electric motors are designed with higher magnetic flux density in the air gap than motors manufactured a half a century ago. Higher magnetic flux density in the air gap produces higher radial magnetic forces acting on the stator system and, consequently, higher vibration and acoustic noise. With the increased power density of electric motors and more demanding environmental requirements, the prediction of noise at the early stage of design of electrical motors has become a very important issue. Not only electromagnetic, thermal, and economic calculations, but also the level of noise and vibration must be considered, so that the overall performance can be optimized/balanced and specific requirements can be incorporated in the design to avoid large retrofit expenses. However, prediction of noise is more difficult and less accurate than, for example, torque--speed characteristics. This is because only a very small fraction of electrical energy is converted in to acoustic energy and correct estimation of some mechanical and acoustic parameters is very difficult.

The first book [119] on calculation of noise in electrical motors was published by H. Jordan in 1950 . Details of harmonic field analysis including harmonic torques, noise, and vibration in induction motors are given in the book [87] by B. Heller and V. Hamata published in 1977. Analysis of noise in induction machines with emphasis on its reduction is given in monograph [248] by S.J. Yang which was published in 1981. The most comprehensive analysis of noise and vibration in electrical machines contains the book [200] by P.L. Timar, A, Fazekas, J. Kiss, A. Miklas, and S.J. Yang published in 1989. It is also necessary to mention two books on noise and vibration in induction machines published by Russian researchers: I. G. Shubov in 1974 [187] and Astakhov, N.V., Malishev, V.S., and Ovcharenko N.J. in 1985 [10], and a book published by Polish researcher S. Kwasnicki in 1998 [127]. There is no book published so far on noise and vibration of permanent magnet (PM) synchronous motors. The demand on these motors is nowadays on the second place after the demand on induction motors.

As most of books on noise and vibration analysis in electrical machines were published over two decades ago, recent advances in vibro-acoustic theories and technologies are only accessible in learned journals and have not been captured in a single monograph. These advances include the development and application of numerical methods of noise computation such as the finite element method (FEM), boundary element method (BEM), and statistical energy analysis (SEA)[43,230]. to the prediction of noise in electrical machines. With the increase in the importance of noise analysis and synthesis in the modern approach to the design of electrical motors, the authors have made an attempt to prepare a modern monograph on noise calculation in induction and PM synchronous motors addressing electromagnetic, mechanical, and vibro acoustic issues. The noise and vibration of switched reluctance motors have not been considered here. The authors have devised the book as both an electrical motor noise textbook and a handbook for electrical machine design engineers, research scientists, and graduate students. The book can also be helpful for multidisciplinary research teams working on noise prediction of systems with electrical motors, e.g.√, electrical vehicles, industrial electromechanical drives, HVAC systems, marine propulsion systems, airborne apparatus, elevators, office equipment, healthcare equipment, etc. The authors hope, that this book will fill the current gap in modern treatment of the analysis and reduction of noise in polyphase electric motors.

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