Optimisation and Comparison of Axial Flux and Radial Flux Electrodynamic Thrust Bearings

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Magnetic bearings ensure contactless levitation of rotors, removing friction and mechanical wear as well as largely reducing the losses. These bearings can be either active, i.e. relying on electromagnets whose current is controlled on the basis of the rotor position, or passive, i.e. solely leaning on passive phenomena. Among the latter, electrodynamic bearings (EDBs) have focused much research efforts as, unlike bearings being only based on permanent magnets, they can levitate all the rotor degrees of freedom, and, in contrast with their active counterparts, they do not require sensors nor power and control electronics. Besides, considering EDB topologies respecting the null-flux principle, namely such that there is no current induced when the rotor is centred, this kind of magnetic bearing can be a priori considered as more reliable, compact and energy-efficient.

Electrodynamic thrust bearings (EDTBs) provide the rotor axial levitation. Their implementation can be based either on an axial flux (AFEDTB) or on a radial flux configuration (RFEDTB). In the last twenty years, two main AFEDTBs topologies have been studied [1][2]. Recently, these two topologies were generalised, thus enlarging the AFEDTB implementations [3]. By contrast, as regards RFEDTBs, only one topology has been proposed so far [4].

Along with these axial and radial flux EDTB implementations came up models allowing us to study the axial dynamic behaviour of this broad range of EDTB topologies [5][3]. The latter model was then extended to take into account the five degrees of freedom characterising the complete dynamics of a rotor whose spin speed is assumed to vary slowly [6]. On this basis, four comparison criteria allowing us to compare objectively intrinsic qualities of EDTBs have been derived [7]. These are related to their stiffness, stability and energy-efficiency. In addition, both motor and passive electrodynamic bearing functions can be combined within the EDTB windings, thereby leading to a passive self-bearing motor whose dynamic behaviour has been modelled in [8]. However, to date, despite the advantages offered by these attractive bearings as well as the existing models and criteria, the potential of AFEDTBs and RFEDTBs still needs to be evaluated and compared.

In this context, this paper introduces a set of new topologies generalising the existing RFEDTB structure. In addition, an AFEDTB and a RFEDTB topologies are optimised via a genetic algorithm and then compared. To this end, the model parameters are identified by means of static finite element simulations and the performance are evaluated through the comparison criteria. Although the two selected topologies can exert a motor torque, this paper only focuses on the bearing function, providing us an upper bound to the bearing performance of such kind of passive self-bearing motors.

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