

Abstract

Permanent magnet (PM) machines are widely industrialized in transportation electrification applications, such as electric vehicles (EV), electric aircraft, and ship propulsion, etc. However, due to their non-adjustable air-gap flux, conventional PM machines still face some critical challenges, especially in terms of the limited constant power speed range, as well as sacrificed efficiency in high-speed region. Aiming to address the above issues, a series of newly emerged variable flux PM (VFPM) machines will be introduced and discussed, with particular reference to the recent developments, future trends, as well as application prospects. First, a “PM+X” concept will be introduced by applying additional field excitation, winding reconfiguration technique, variable leakage flux property, mechanical adjusted device and low coercive force magnet to the conventional PM machines. Besides, the topology features, working principle, and control schemes of VFPM machines will be addressed, respectively. Finally, some challenges and opportunities for VFPM machines and drives, as well as their potential applications will be summarized.