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Chapter 1

Introductory Chapter: Electric Machines for Smart Grids and Electric Vehicles Applications

Adel El-Shahat

Additional information is available at the end of the chapter

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1. Introduction

The rule of electromechanical vitality change was first shown by Michael Faraday in 1821. The first electric machine, really a DC one, was imagined by William Sturgeon in 1832. Nikola Tesla considered the turning attractive field in 1882 and utilized it to develop the first AC machine, really an enlistment engine, in 1883. Now the AC machines, including synchronous generators and enlistment generators, have been broadly acknowledged to function admirably for nonrenewable energy source control age. As of now, all electric machines for sustainable power source collecting are reached out from nonrenewable energy source control plants. Conventional generators are moderately ineffectual to change over sustainable power sources into power, especially inefficient for tackling wind power or wave one [1].

In September 1821, Faraday constructed a first electric motor utilizing a compartment of mercury with a permanent magnet in its inside. At that point, Faraday spent the following decade, on and off, attempting to comprehend the material science behind electromagnetism. At that time, he depicted various fizzled analyses in which he attempted to show what is called "electromagnetic induction." From that point onward, Faraday's superseding inspiration was to "change over magnetism into electricity," and it was "Arago's disk" that was the platform for his delightful analyses. His analysis demonstrated that a current could be actuated all the time when there was relative movement between the conductor and the attractive field. We presently know this impact as "electromagnetic induction." He next found an undeniably compelling method for changing the magnetic field: by moving two wires, one associated with a battery and the other to a galvanometer. Faraday's induction ring was, essentially, the simple first electrical transformer. It gets by right up till the present time and is in plain view in the Royal Institution's historical center as shown in **Figure 1** [2].

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Figure 1. Faraday’s induction ring (1831) [2].

The American researcher, Joseph Henry (1797–1878), from numerous points of view, reflected that of Michael Faraday, was additionally working autonomously on electromagnetism on the opposite side of the Atlantic—in spite of the fact that enthusiasm for the subject was absolutely circling over the Atlantic by the 1830s. Henry in certainty beat Faraday to the disclosure of inductance by a couple of months in 1831, yet it was Faraday who distributed first and, in spite of the defers that so baffled him, is in this way credited with the revelation. The French instrument producer, Hippolyte Pixii (1808–1835), constructed an unrefined electric generator as ahead of schedule as 1832, constructed specifically in light of Faraday’s thoughts of enlistment. A recommendation by Ampère and others prompted the presentation of the commutator—a revolving switch that inverts the association with the outer circuit when the present turns around, giving a beating DC current rather than an AC one. A business, substantial-scale use of Faraday’s disclosure was made by the electroplaters of Birmingham as right on time as 1844. The pace of innovation at that point got in the 1850s as plans for evermore groundbreaking generators known as “magnetoelectric machines” were produced fully expecting the business uses of the electric machine [2].

By the mid-1860s, some researchers and innovators were creating handy outlines for the dynamoelectric machine. These gadgets were utilizing self-controlling electromagnetic field curls rather than lasting magnets to empower far more noteworthy power age out of the blue. By the 1880s, the alleged “war of the streams” was going all out between those, for example, Thomas Edison, who favored DC current for control age and those, drove by George Westinghouse and Nikola Tesla, who trusted that AC current was the path forward. The last two would, in the end, unequivocally win that intense war. The advancement of AC control transmission, utilizing transformers (whose causes lie in Faraday’s straightforward enlistment ring) to transmit power at high voltage and with low misfortune, permitted focal influence stations to wind up financially down to earth. Today, the alternator overwhelms huge-scale power production and depends on a liquid, normally steam, that goes about as a transitional vitality transporter, to drive the turbines and produce power.

2. Permanent magnet (PM) machine overview

PM synchronous machines have been a point of enthusiasm for the last quarter century. Previously, AC synchronous machines were utilized for the most part of generator applications. Their utilization as a motor was restricted because of the trouble of controlling the frequency of their supply voltages. The presentation of intensity gadgets PWM inverters has enabled the motor drive to have finish control over the extent and recurrence of machine stage to stage voltages. Another factor that helped the improvement of PM synchronous machines is the development of mechanical creation of permanent magnets. The permanent magnet composed to be delivered on a modern scale was the Alnico in the mid-twentieth century. The rotor of line-begin PMSM is made of lasting magnet installed inside a squirrel-confine winding. Enlistment of current in the squirrel confine produces torque at zero or higher paces; a similar way torque is created in acceptance engines. PMSM with line-starting can create torque at zero speed and keep running as an enlistment engine, until the point that the synchronous speed is reached [3, 4]. Once the synchronous speed is achieved the rotor is synchronized with the power source. After this, the motor keeps running as a synchronous motor.

However, high-speed PM machines permit a lessened framework weight, higher working proficiency, diminished upkeep costs, and a littler envelope than a customary arrangement in a similar power rating. Notwithstanding with the higher-power thickness and frequency likewise comes higher-power misfortune thickness. Exceptional consideration should then be paid to the decision of overlay material, loop development, and cooling component for what might somehow be a normal stator and lodging plan. On account of a rapid PM motor, temperature affectability of the magnet material is an extra factor. Hence, samarium cobalt is frequently the decision to acknowledge higher-temperature plans [3, 4]. Permanent magnetic machines can be generally divided into subgroups as shown in **Figure 2**. In addition, **Figure 3** illustrates schematic cross section of a four-pole motor with surface-mounted permanent magnets and an interior PM motor.

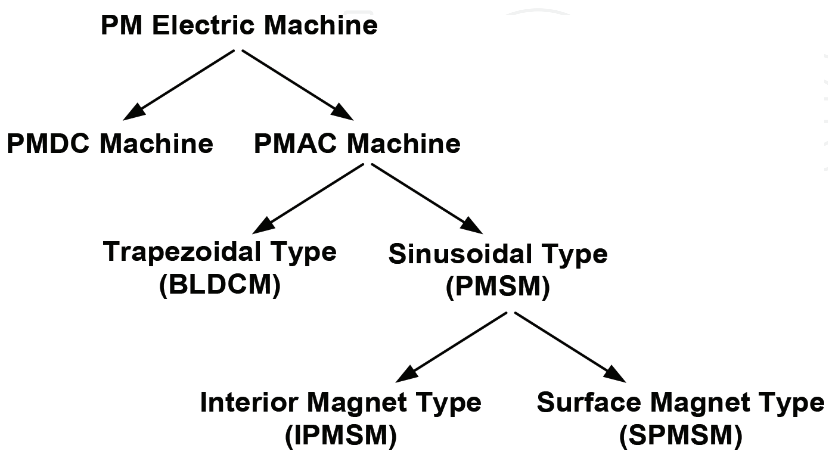

Figure 2. Permanent magnetic machine subgroups.

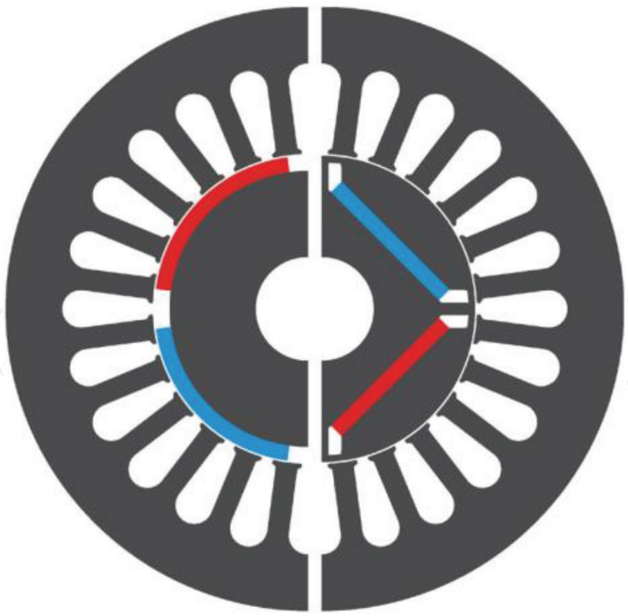

Figure 3. Schematic cross section of a motor with surface-mounted permanent magnets (PM; left) and of an interior PM motor (right) [3].

3. Editor's contributions to this field

This book has recent advances of modeling, control, optimization, analysis, and design of electric machines especially for smart grid applications and electric vehicles. However, the editor himself has some contributions for different types of electric machines in many applications as the following: electric machines (EM) in nano-power grids [5]; EM in smart home systems [6]; performance improvement for induction motor [7]; PM synchronous machine new aspects for modeling, control, and design [8]; sizing high-speed micro-generators for smart grid systems [9]; high-speed PM generator for optimized sizing based on particle swarm for smart grids [10]; EM in small-scale hydropower generator electrical system modeling [11]; for ANN robot energy modeling [12]; small-scale wind power dispatchable energy source modeling [13]; PMSM sensorless speed control drive [14]; ANN interior PM synchronous machine performance improvement unit [15]; PMSM performance improvement [16]; sizing a high-speed PM generator for green energy applications [17]; 400 kW six analytical high-speed generator designs for smart grid systems [18]; nonlinear global sizing of high-speed PM synchronous generator for renewable energy applications [19]; micro-generator design for smart grid system (comparative study) [20]; PM synchronous motor drive system for automotive applications [21]; high-speed PM synchronous machine [22]; PM synchronous motor dynamic modeling with genetic algorithm performance improvement [23]; spacecraft flywheel high-speed PM synchronous motor design (classical and genetic) [24]; high fundamental frequency PM synchronous motor design neural regression function [25]; PM synchronous motor control strategies with their neural network regression functions [26]; high-speed PM generator optimized sizing based on particle swarm optimization for smart grids [27]; energy modeling of differential drive robots [28]; high-speed micro-turbine modeling and control for micro-grid applications [29]; optimized sizing of high-speed PM generator for renewable energy applications [30]; PM synchronous motor genetic algorithm performance improvement for renewable energy applications [31]; high-speed synchronous motor basic sizing neural function for renewable energy applications [32]; PM synchronous motor genetic algorithm performance improvement for green energy applications [33]; high-speed PM synchronous motor basic sizing neural regression function for renewable energy applications [34]; permanent magnet synchronous motor dynamic modeling [35]; generating basic sizing design regression neural function for HSPMSM in aircraft [36]; neural unit for PM synchronous machine performance improvement used for renewable energy [37]; PM synchronous machine stabilization control for electric vehicle [38]; neural unit for PM synchronous machine performance improvement used for renewable energy [39]; PM synchronous machine stabilization control for electric vehicle [40]; PM synchronous machine stabilization control for aircraft and spacecraft [41]; dynamic modeling of permanent magnet synchronous motor using MATLAB-Simulink [42]; speed sensorless neural controller for induction motor efficiency optimization [43]; neural model of three-phase induction motor [44]; and high-speed switched reluctance motor generator for automotive turbocharger applications [45].

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