Chapter 21
A Black-Box Model for Estimation of the Induction Machine Parameters Based on Stochastic Algorithms

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ABSTRACT

Knowledge on asynchronous machine parameters (resistances, inductances…) has become necessary for the manufacturing industry in the interest of optimizing performances in a production system (roll-to-roll processing, wind generator…). Indeed, accurate values of this machine allow improving control of the torque, speed and position, managing power consumption in the best way possible, and predicting induction machine failures with great effectiveness. In these regards, the authors of this paper propose a black-box modeling for a powerful identification of asynchronous machine parameters relying on stochastic research algorithms. The algorithms used for the estimation process are a single objective genetic algorithm, the well-known NSGA II and the new θ-NSGA III (multi-objective genetic algorithms). Results provided by those show that the best estimation of asynchronous machines parameters is given by θ-NSGA III. In addition, this outcome is confirmed by performing the identification process on three different induction machines.

1. INTRODUCTION

Over the past decades and more specifically since the 70's, the manufacturing industries have deployed significant resources in the improvement of their production method to reach a higher ambitious level than that of competitors. Indeed, in the background of globalization and trade liberalization, companies' survival depends on their capacities to provide a high quality/price rate for their products (Dawar &

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Frost, 1999). In the pursuit of this goal, industries have taken advantage of the rapid development of computers computing power (More's law) (Schaller, 1997)that further increases their competitiveness and productivity by applying several strategic changes, such as automation and optimization of production lines generally composed of conveyors, electrical machines and sensors. This research focuses on the induction machine, which is the main element of automation systems. This machine is considered as the most often used motors in industries because of its ease of implementation and its sturdiness (Boldea & Nasar, 2010).

As a consequence, the optimal exploitation (optimization) of the automated production lines to increase the production efficiency is mainly based on an accurate knowledge of parameters of the asynchronous machine, such as resistances and inductances on the stator and the rotor. Indeed, accurate values of this machine allow computing the closed-loop, drive-fed motor (e.g. speed optimization), managing power consumption (e.g. saving 5% of power consumption) in the best way possible, designing an electrical installation as precisely as possible (e.g. optimal exploitation for the greatest installation lifespan), and predicting induction machine failures with utmost effectiveness (e.g. predictive maintenance optimization).

This expectation can be provided by predicting the behavior of the induction machine. In order to predict the asynchronous machine behavior, the induction motor parameters have to be extracted. There are two major approaches to obtain these parameters. The first one is based on off-line techniques (external measurements, optimization algorithms) (Babau, Boldea, Miller, & Muntean, 2007; P. Kumar, Dalal, & Singh, 2014; Salimin et al., 2013), and the second relies on on-line methods (Recursive Least Square, Extended Kalman Filter…) (Vieira, Azzolin, Gastaldini, & Gründling, 2010; Yazid, Bouhoune, Menaa, & Larabi, 2011). In this paper, is the authors' focus is on the optimization algorithms, and more specifically on the Evolutionary Algorithms (EAs). These algorithms have proved their efficiency in the optimization and identification domain (Cantelli, D'Orta, Cattini, Sebastianelli, & Cedola, 2015; Shafiei & Binazadeh, 2015).

EAs are the most common algorithms; they are currently used in industries and academic researches. Indeed, they allow seeking solutions to complex optimization problems by using the stochastic methods and estimating a criterion called objective function (or fitness function). The main advantage of these algorithms is that they do not need to estimate the derivative of this function, unlike traditional optimization algorithms. Accordingly, EAs, in particular Genetic Algorithms (GAs) are very popular for identification processes.

EAs, more specifically, GAs, Multi-Objective GAs and Particle Swarm Optimization (PSO) are broadly applied to estimate parameters of induction motors. In different papers (Huynh & Dunnigan, 2010; Karimi, Choudhry, & Feliachi, 2007; Yousfi, Bouchemha, Bechouat, & Boukrouche, 2013), researchers assert that PSO are more efficient than GAs. Nevertheless, because of the lack of information (especially the searching boundaries) on the identification parameter and the number of tests achieved, the difference between GAs and PSO could be negligible.

Hence, the authors propose a black-box model for an overcome identification of 5 parameters of the asynchronous machine relying on stochastic research algorithms. This mathematical representation of the induction motor is the most used model to compute the closed-loop control. It also allows simulation of complex production processes (roll-to-roll system…) or electrical energy creation (wind turbine…). Furthermore, accurate knowledge of the asynchronous machine parameters is essential for an optimal design of applications exploiting this motor as mentioned above. This work presents a comparison of identification parameters between the single objective GA and two multi-objective GAs, namely the well-known NSGA II and the new θ-NSGA III. The exploitation of the multi-objective definition in this