"STUDY ON EFFICIENCY OPTIMIZATION OF INDUCTION MOTOR AND TECHNIQUES"

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ABSTRACT: *Today, electric motors have become an integral part of the modern industry. In very large power ranges, motor drives are used. The drives are operated by a power electronic converter, an interface between the input power and the motor, in multiple applications where speed and position control is of great significance. It has become kind of demand by both the users and the manufacturers to optimize the design to improve the performance in terms of efficiency, torque and material cost. Nowadays optimization of induction machine is making trade-off between different objectives such as a particular item of performance, cost of machine or quality or reliability. The paper presents a study of developments in the field of three-phase induction engine performance improvement by optimal control. Both the large methods, loss model control and search control, are explicitly protected by optimal control. This paper also reviews the use of artificial intelligence techniques such as artificial neural networks, fuzzy logic, expert systems, and algorithms inspired by nature; genetic algorithms and differential optimization evolution.*

Keywords: Three-Phase Induction Motor, Artificial Intelligence, Efficiency, Torque, Loss Model Control, Search Control

1. INTRODUCTION

The induction engine is a commonly used electric motor and a major source of electricity. For heating, ventilation, and air conditioning, the vast majority of induction motor drives are used. Improving electric motor efficiency and its impact on energy savings is now becoming a major challenge for researchers and manufacturers worldwide. More than half of all electricity generated is used by electric motors, with a standard range of 40-60 percent, the lower and upper limits for developing and developed countries, respectively. The industrial sector absorbs roughly 60-80 percent and 20-40 percent of the tertiary sector. Induction motors account for about 90 percent of the total consumption of electric motors, as seen in [3]. These statistical data on the worldwide electric motor park represent this subject as a leading area of energy saving research and highlight the increasing interest in improving electric drive systems, motor efficiencies in general and induction motor efficiencies in particular.

Currently, the implementation of artificial intelligence software to optimize computer design parameters is among the design trends in improving the efficiency of electrical machines. This primarily contributes to improving their efficiency, power to mass ratio and cost.

While genetic algorithms can quickly locate the region where the global optimum occurs, it is relatively time-consuming to locate the exact local optimum in the convergence region [5]. To find the exact global optimum, a combination of a genetic algorithm and a local search method will speed up the search.

In such a hybrid, applying a local search to the solutions that are directed by a genetic algorithm to the most promising area will accelerate convergence to the global optimum. If local search methods and local knowledge are used to accelerate the location of the most promising search region, in addition to locating the global optimum starting within its attraction basin, the time needed to reach the global optimum can be further reduced.

2. RELATED WORK

Abhishek Choudhary et. al [1] When operated by a PWM inverter, the energy expended in a 3 HP induction motor drive is compared with an unregulated motor operating at the same speed under the same 3.1loading conditions and THD calculations are done for both.

Branko Blanuša et. al. [2] introduces a new hybrid model for performance optimization of induction motor drives (IMD). It incorporates two performance optimization strategies: control of the loss model and control of search. The search control technique is used during transient processes in a steady drive and loss model state. As a result, power and energy losses are reduced, especially when the rated value of the load torque is significantly lower. The hybrid method provides rapid convergence of minimal power losses to the operating point and displays negligible sensitivity to changes in motor parameters with regard to other published optimization strategies.

V. K. Gupta et. al. [3] provided a summary of the developments in the field of three-phase induction motor performance optimization via optimal control. An analysis of different optimal control methods in real time was presented.

S. Chekroun et. al. [4] explains the procedure for determining the design of electric three-phase motors. In order to achieve the optimum objective function, such as motor efficiency, the originality lies in integrating a motor design programme and using a Hybrid Genetic Algorithm (HAGs) technique.

Hamid Reza Mohammadi et. al. [7] starting torque, the full load torque, the maximum torque, and the full load power factor usually available from the manufacturer's data are used for problem formulation. In the steady-state equivalent circuit, the proposed approach is used to estimate the stator and rotor resistances, the stator and rotor leakage reactance's, and magnetizing reactance. To minimize an objective function containing the error between the estimated data and the producer, the optimization problem is formulated.

3. CLASSIFICATION OF INDUCTION MOTORS

The drives of the induction motor are roughly categorized into two groups, i.e. Control Scalar and Control Vector.

3.1 Scalar control

Basically, scalar control strategies are simple and less precise, and only the magnitude of the control variable is altered. As a result of the coupling effect of flux and torque, these techniques are essentially slow.

3.2 Vector control

Vector control, also referred to as field-oriented control (FOC), is a form of control of the variable frequency drive (VFD) in which the stator currents of a three-phase AC electric motor are recognized as two orthogonal components that can be visualized with a vector. The variables are converted into a reference frame in this technique, in which the dynamic variables are like quantities of DC. The regulation of decoupling between the flux and torque enables quick transient response to be achieved by the induction motor.

3.3 Indirect Vector control

There are basically two general vector control methods. The direct or feed- back method and indirect or feed forward method differ in the way the angle of the rotor is calculated. The angle is obtained by terminal voltages and currents in direct FOC, while the angle is obtained by means of rotor position calculation and system parameter calculation, as in indirect FOC.

3.4 Direct Vector Control

The rotor angle or control vector in direct FOC [5] is directly obtained by the terminal voltages & currents using flux estimators. Direct vector control is also known as a vector control scheme for feedback. Similar to Indirect Vector Control, different controllers have been introduced to boost the efficiency of the drive on direct vector-controlled induction motor drives.

Although the direct approach is inherently the most desirable control device, it suffers from high costs and flux calculation unreliability. Although the indirect method can approach the efficiency of the direct measurement system, the key drawback of this approach focuses on the precision of the control gains, which, in turn, are heavily dependent on the engine parameters assumed in the algorithm of feed forward control.

4. OPTIMIZATION TECHNIQUES

Currently, research efforts have been made to invent novel optimization methods that have the characteristics of memory updating and population-based search methods to solve real life problems. Optimization techniques for general purposes, such as hybrid genetic algorithms (HAGs) and genetic algorithms (GAs), have become common optimization techniques. The main is:

4.1 Genetic Algorithms

The optimization based on the genetic algorithm is a stochastic search method that involves the random generation of possible design solutions, then tests and refines the solutions systematically until a stopping criterion is met. The search method of a genetic algorithm requires four fundamental operators: Population, Selection, Crossover, and mutation.

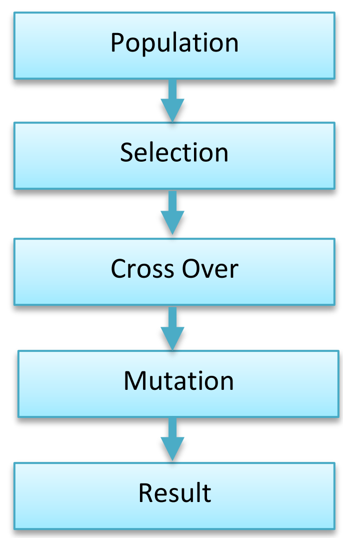

Figure 1: Step of Genetic Algorithm

4.2 Simplex Method

A robust nonlinear multi-dimensional optimization technique is the Simplex form. The method does not require optimization of the derivation of the equation. A simplex is a geometrical figure consisting of (N+1) vertices, in N dimensions. The Simplex method starts with the initial simplex (N+1) points, then transfers, extends and contracts the initial simplex through a transformation (reflection, contraction and extension), in such a way that it adapts itself.

4.3 Particle Swarm Optimization

The PSO is a form of stochastic optimization that uses swarming behavior found in bird flocks. In reality, the sociological activity associated with swarms motivated the PSO. As a new heuristic method, the PSO was created by Kennedy and Eberhart in 1995. A particle in the PSO algorithm is a possible solution to the problem of optimization and keeps track of its coordinates in the space of the problem and attempts to Search for the best location by flying in a multidimensional space associated with the best solution (called the best fitness) so far, called pbest. The overall best value is another 'best' value called 'gbest' that is monitored by the global version of the particle swarm optimizer, and each particle in the swarm has so far obtained its position. Via prior experience, its current velocity, and the experience of the neighbouring particles, each particle explores its search space. The definition of the PSO is the change in each particle's velocity towards its pbest and gbest locations in each iteration

4.4 Hybrid Genetic Algorithm

A main objective of the GA research efforts is to find a type of algorithm that is stable and performs well over a number of types of problems. While genetic algorithms can quickly locate the area where the global optimum occurs, it takes a relatively long time for the exact optimum to be located in the convergence zone. The search can be accelerated by a combination of a GA and a local search approach to find the exact global optimum. Convergence to the global optimum can be accelerated by applying a local search to the solutions that are directed by a GA to the most promising area in such a hybrid [5]. There are many ways to hybridize all systems, based on maintaining an appropriate modular programmed structure for GAS. This way, you just have to let it run until the convergence of the genetic algorithm, so the level then allowed the Simplex algorithm to take over the optimization method, taking, for example, 5 percent or 10 percent of the last generations' best individuals.

4.5 Other Techniques

The approach suggested in [8] is a little bit different. In the algorithm, the authors used the Fuzzy logic controller to produce the reference speed for optimal energy consumption for belt conveyors. The suggested control structure is created and tested with the rubber belt on the detailed mathematical model of the drive system. The algorithm presented is implemented with remote control on an open pit mine on the new variable speed BC system. The measurements were performed during the eight months of exploitation to verify the proposed concept. Pontryagin's maximum principle is used to improve the efficiency of induction motors during the acceleration and deceleration period in [9]. The authors of [10] noted that, due to different operating conditions and transient in EVs, parameter variations affect the output of the induction motor drive used in the electric vehicle. A novel IM modeling approach is presented in which the motor parameters of different operating conditions are calculated using an off-line method from transient data information, and a correlation analysis is used to map the parameters to operating conditions.

5. OPTIMAL EFFICIENCY PROCESS

The technique of minimizing motor loss by changing the degree of motor flux according to the motor load is called optimal energy management, also known as management of performance optimization or control of loss minimization or optimal loss control. Activity for effectiveness. If the number of the induction motor failure components is minimum, the optimum operating point is reached at nominal speed and torque, induction motors have high performance. The iron losses, however, increase drastically at light loads, reducing efficiency considerably. The flux at the rated value causes excessive core loss at light loads, as it is more than sufficient for the required torque production. Motor induction losses are usually divided into five components: losses of stator copper, losses of rotor copper, losses of iron, losses of mechanical and stray losses. A analysis of the copper components and core losses shows that their patterns are contradictory. The copper losses begin to diminish as the core losses increase. The induction engine's electromagnetic torque can be approximated by

$t_e = k_{tc} l_m \, l_r$………………………… (1)

Where: t_e: Electromagnetic torque

l_m: Magnetizing current

l_r: Rotor current

k_{tc}: Constant

The electromagnetic torque of the induction motor can be produced from the equation (1) by the number of combinations of magnetization and torque producing the rotor current. Thus, the same torque can be achieved with a different combination of flux and current value. A magnetizing current exists for any load and speed state, where motor losses are small. Therefore, it is well recognized that there are several distinct combinations of input voltage and frequency for a given load torque to generate this operation. Their efficiencies are different, but there is an air-gap flux density for that given load torque, at which the total losses are reduced, with a small loss in speed accuracy. Thus, the method of reducing electrical losses essentially comes down to the selection of the operation’s acceptable air-gap flux density. The same can be interpreted in the vector control scheme as optimum performance can be achieved at a given value of stator current. However, the challenge for engineers is to be able to predict the required flux values over the full torque and speed range at every operating stage, which will reduce machine losses, thereby optimizing performance.

6. CONCLUSION

Optimization of productivity is very critical not only for electrical systems, but also needs all systems to benefit from money and also reduce global warming. This paper provided a summary of the developments in the field of three-phase induction motor performance optimization via optimal control. An analysis of different optimal control methods in real time was presented. This paper also includes the use of Artificial Intelligence (AI) techniques such as artificial neural network (ANN), fuzzy logic, expert systems and algorithms inspired by nature (NIA), genetic algorithm, and differential optimization evolution.

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