ABSTRACT

Electric motors, which are predominately of the three phase induction motor, squirrel-cage type, consume about 60% of electrical energy generated in industrialized countries. Induction motor have long life span and rugged in structure, such that the requirement and maintenance cost is the least. In industrial environment, an induction motor needs starting first and variable speed operation next. It is also recommended to have energy efficient operation during light load conditions. In the present work, attempts have been made to design and develop soft starter for induction motor, variable voltage, variable speed operation and efficiency enhancement operation during part load conditions. Towards these objectives, a few biological inspired optimization algorithms have been employed and many of them are successfully implemented on a laboratory model.

In this thesis work, the following methods have been developed and successfully tested on a laboratory model.

i) Soft starting of induction motor through Genetic Algorithm(GA) and Particle swarm optimization(PSO)

ii) Variable speed operation of ac voltage controlled induction motor through Fuzzy logic controller and Ant colony optimization.

iii) Energy efficient operation of thyristorised voltage controlled induction motor drive under light load conditions through Neuro-Fuzzy controller.
Direct online starting of large ac motors may present difficulties for the motor itself and the loads supplied from the common coupling point because of voltage dips in the supply during starting, especially if the supply to which the motor belongs is weak. An uncontrolled starting may cause a trip in either overload or under voltage relay, resulting in starting failure. This is troublesome for field engineers since the motor cannot be reenergized until it cools down to an allowable temperature in a long time period. Furthermore the number of starts per day is limited to only a few attempts. Therefore the current and torque profiles of motor during starting are to carefully tailored according to the needs of the load.

A soft starter is a thyrisotorised ac voltage regulator which applies reduced voltage to the motor at start and increases the applied voltage with limit on motor current. The soft starter is cheap, simple, reliable and occupy less volume and hence their use is a viable solution to the starting problem of large motors. Several works have been published in the literature for the soft starting of induction motor; however most of the works use repeated simulation study to find an appropriate design for the soft starter. The use of neural network and fuzzy logic controller has also been employed for induction motor soft starter. The application of biological inspired optimization algorithm and subsequent implementation are not seen in the literature.

In the present work, the induction motor soft starting is formulated as an optimization problem and solution is achieved using Genetic Algorithm (GA) as well as Particle swarm optimization (PSO). The time-varying, state space model of induction motor is suitably integrated with these two optimization algorithms and optimal Proportional controller (PI) constants are identified. Computer simulation results and experimental measurements
carried out on laboratory motor indicate the effectiveness of the proposed method.

Of the principle schemes for induction motor speed control, the variable-voltage, constant frequency type is simple, economical and increasingly employed in low to medium power applications, especially where the load torque varies as the square of the motor speed. Such applications are typically compressor, pump and fan loads. In this scheme, stator voltage is controlled smoothly at line frequency between zero and full value by symmetrically controlling the firing angle of SCR devices. Although variable-voltage, constant frequency control of induction motor is one of the simplest schemes of speed control as it is a naturally commutated system, the analysis of such systems is extremely complex. In this thesis work, a small signal model is developed at typical operating point and proportional integral (PI) controller is used for speed regulation. Since ac voltage controller fed induction motor drive is a non-linear system and its parameter vary with operating point it is found that best dynamic response of drives can be obtained only by tuning the PI controller parameters at each operating point, which is very difficult to accomplish online. Hence a Fuzzy logic controller is derived after analyzing the dynamic response of the speed control with traditional designed controller. The speed control of the drive with Fuzzy logic controller is simulated and subsequently verified. The results shows that dynamic response of different operating point of the drive.

The concept of Ant colony optimization (ACO) is also used for optimal tuning the Proportional Integral (PI) controller of the speed control system at typical operating point. Here the design of controller is referred as an optimization problem with peak overshoot and settling time of the motor speed response incorporated in the objective function. It is found that Ant
colony optimization (ACO) tuned controller give excellent results when used with variable speed operation.

For the energy efficient operation of the motor, a proposal is made to estimate the firing angle for the ac voltage controller during light load conditions. From the experimental observations, it is observed that optimum SCR firing angle can be expressed as a function of optimal value of motor current during the previously optimized condition and motor current at the operating point. However this characteristic relationship is observed to be largely non-linear and hence based on several practical operations on the drive system with various load conditions a fuzzy rule based is developed. Since fuzzy logic operation demands more computing time, a neuro-fuzzy system is developed and is used for energy efficient operation. Extensive simulation results are carried out to prove that the proposed scheme enables energy efficiency.