ABSTRACT

This thesis work deals with the investigations carried out on electric drives at three different stages, namely their design, construction and operation, with the aim of achieving energy efficiency. Improving the efficiency of electrical equipment is now recognized in many countries as a less costly means than construction of new power plants for meeting some of the increased demand for electricity services.

With the aim of developing Energy Efficient Induction Motor (EEIM), design optimization is carried out. Optimal design problem is considered as a non-linear multi – variable constrained problem. Imposition of a multitude of constraints makes optimization tedious. In this work, the well established robust optimization techniques, Genetic Algorithms and Differential Evolutions are used for developing EEIMs. Based on the optimal design results obtained by Genetic Algorithm Technique, two EEIMs have been developed. Their ratings are 11 kW and 3.7 kW, 415 V, 3-phase, 50 Hz, 4- pole. Another 11 kW , 415 V , 3-phase , 50 Hz , 4-pole EEIM has also been developed with the results obtained by Differential Evolution Technique.

Two different constructional modifications are carried out leading to the development of energy efficient Permanent Magnet Induction Synchronous Motor (PMISM) and high frequency submersible motor pump.

For most of the industrial applications, Induction motors are preferred due to their robust construction, higher reliability and maintenance free operation. However, they have the disadvantages of decrease in speed with increase in load and low power-factor. To overcome the above disadvantages, development of Permanent Magnet Induction – Synchronous Motor (PMISM) is suggested. The developed PMISM integrates the features of Permanent Magnet (PM) motors with those of conventional Induction and Synchronous motors. Combination of squirrel cage rotor with interior permanent magnet geometry provides possibilities for efficient steady state operation and good line starting. The synchronous operation eliminates the rotor copper loss which leads to improvement in efficiency. A prototype 1-phase, 0.75 kW, 230 V, 50 Hz , 2-pole PMISM has been designed, developed and tested.

Attention was also given to Induction motors employed in agricultural pumping sector. In order to utilize the available ground water below 120 m depth, efficient bore-hole multistage submersible pumps are required. Due to the limitations in the diameter, the number of stages required in the conventional pumping system is very large for the high head applications. This leads to more moving parts and low efficiency. The performance of the pumping system can be improved considerably when operated at higher speeds i.e. more than 3000 rpm, which is the limiting speed for a 50 Hz motor with 2-pole construction. In this context, single stage submersible motor pumps of 2.2 kW for 100 mm size and 9.3 kW for 150 mm size bore wells for heads of 60 m, 2.0 lps and 120 m, 4.0 lps respectively in stainless steel body have been developed. They are operated with a microprocessor based controller capable of varying frequency up to 200 Hz. When the rotor speed is increased the rise in each stage is found to be very high. This leads to reduction of number of stages to either 1 or 2.

Achieving energy conservation during operation, especially on partly loaded 3-phase Induction motors, fuzzy logic controllers have been developed and presented. Variable voltage operation of partly loaded Induction motor has attracted the attention of many researchers as a means of energy conservation. In a lightly loaded Induction motor , a large amount of energy is wasted which can be conserved by voltage control. There is a distinct stator voltage for each load condition for optimum performance. The fuzzy logic control approach is found to be very useful for Induction motor drives since no exact mathematical model of the Induction motor or the related closed loop system is required . A laboratory prototype fuzzy logic controller has been designed, developed and tested with 0.37 kW , 3–phase , 50 Hz , 4-pole Induction motor . The fuzzy logic controller adjusts the terminal voltage of the motor continuously, based on sampled values of current feedback, in order to maximize the efficiency of operation at any given load.

Modern computer and telecommunication systems place heavy demands on the availability and quality of the power supply . Invariably Uninterruptible Power Supply (UPS) system is used everywhere as a power conditioner. In this work, augmentation of solar photovoltaic supply with Electricity Board (EB) supply is carried out through supervisory controllers for energy conservation . A battery monitoring circuit in the developed controller samples the battery voltage , solar panel voltage and the EB supply continuously and switches over between two modes (stand alone mode or grid interface mode) or sounds an alarm if both the primary source (EB supply / solar photovoltaic supply) and secondary source (battery) fail. Sufficient energy conservation has been achieved by the proposed controller.

New equation for slip at which the 3-phase Induction motor operates at its maximum efficiency on a specified input voltage has been derived and presented. With the help of the newly derived formula, a novel prediction method for energy efficient operation of 3–phase Induction motors is formulated which greatly simplifies the concept of voltage control in partly loaded condition . The prediction method is based on the approximate equivalent circuit model of 3–phase Induction motors. The variation of shunt branch elements of the equivalent circuit with the supply voltage is taken care of. Several sample motors have been tested and the performance parameters like efficiency and slip compared for rated and reduced voltage operations at all load conditions . Test results confirm the validity of the proposed method.