Chapter 1

Introduction and Contents of the Thesis

1.1 INTRODUCTION

Energy conservation continues to get higher and higher attention at National & International levels. Various government and private agencies along with Green activists are propagating higher and higher acceptance norms on efficiency of various products. All these have resulted in the need of test procedures for efficiency measurement which are more precise, reproducible and have better co-relation with actual energy consumption.

Normally performance determinations mean the determination of efficiency, power factor, speed, current etc. The determination of efficiency of the motor on line involves measurement of torque developed by the motor and speed of the motor. For this purpose of measuring torque it is require to connect, the torque transducer mechanically with motor shaft. There is a practical difficulty in the insertion of transducers for the torque measuring on electro-pumping groups related with the mechanical disconnection of coupled machines. This is sometimes not fast or even not feasible.

A number of induction machines modeling methods are available for different types of application, namely machine dynamics and control [1] steady state starting performance analysis [2],[3], steady state efficiency and torque evaluation at or under rated conditions [4], [5], [6], [7] as well as for different rotor types (single-, double cage-, wound-rotor) and power supply waveforms [3],[7]. Besides model structures, parameter identification and test procedures are of special concern when specific studies require especially accurate modeling.

Standard test procedures have been established for a variety of situations following a long and valuable experience in the field [8]. The efficiency estimation of induction motors is treated in the most important international standards in the field, namely IEEE Std. 112 and IEC 60034-2. The key issue in efficiency evaluation is the determination of all losses in the machine. Besides copper losses, Iron losses, friction and windage losses, the STRAY LOAD LOSSES (SLL) represent a non negligible part in the summation. These last are difficult to evaluate accurately and some studies [4], [6] have been devoted to the comparison of standard methods for that purpose, especially those in IEEE Std. 112 and IEC 60034-2: the simplest approach uses assumed values according to machine rating, that may be still corrected by the square of rotor current, or even using more complex solutions as in IEEE 112-method B.

As the direct torque measurement is not feasible in some cases the efficiency evaluation based on equivalent circuit is presented in chapter 2 and 5. A numerical procedure using a Newton-Raphson method for the calculation of Induction motor model parameters is presented.

1.2 SPEED CONTROL

Human and animal powers are the traditional modes of power utilized by mankind to drive different types of machines required by the people during various stages of development. What-wheels are believed to have been used in China around 3000 BC. This was the first crude means of mechanization. Later it was the wind power and after the industrial revolution, steam power and IC engines were developed for driving machines. However, by the end of the nineteenth century, three-phase ac power becomes available which completely transformed the nature of industrial drives. The electric motors have now become the main source of driving equipment. An electric drive has so many advantages over other forms of drives that it has replaced almost all of them in industrial applications.

The electric drive makes use of electric motors as prime movers. The electric motors have the advantage that they can be brought very close to the working machine (thus eliminating the transmission links), can be operated at any desired speed and can be started and reversed in very short periods of time. The electric motors are available in a wide range of power ratings, from one watt to few thousand of kilowatts capacity. These motor are now electronically controlled using solid state circuit for starting, reversing and speed control. The electric drives are therefore very efficient, less expensive, and reliable. With the availability of such a wide range of motor capacities with simple control circuit, it is possible to develop efficient drives to meet any requirement of modern industries.

An important factor in industrial progress during the past five decades has been the increasing sophistication of factory automation which has improved productivity manifold. Control motion or speed of electrical motors in general plays very important role in modern industries, commercial buildings and house hold appliances.

In number of applications motor must satisfy the speed requirement. For example speed of electric fan. As per the requirement of comfort of the persons it must throw an air and that is possible only by adjusting fan speed. However, there are certain industrial applications where motor must have wide speed range and speed should vary smoothly or should have step-less variation as economically as possible. Consider an example of train driven by electric motor. In this case motor has to accelerate very heavy weight consist on number of bogies along with passengers. Here motor is required to perform very stringent duty as speed should increase smoothly and jerk-less so that it will not create any discomfort to passengers and at the same time speed should increase very fast so that acceleration time can be reduced. This may not possible for all motors and all the time. From the speed control point of view induction motors are inferior to the dc motors. The speed of dc motor can be adjusted in wide range with good efficiency and speed regulation with relatively low cost equipments which is not possible for an induction motor.

Manufacturing lines typically involve a variety of variable speed motor drives which serve to power conveyor belts, robot arms, overhead cranes, steel process lines, paper mills, and plastic and fiber processing lines to name only a few. Prior to the 1950s all such applications required the use of a DC motor drive since AC motors were not capable of smoothly varying speed since they inherently operated synchronously or nearly synchronously with the frequency of electrical input. To a large extent, these applications are now serviced by what can be called general purpose AC drives. In general, such AC drives often feature a cost advantage over their DC counterparts and, in addition, offer lower maintenance, smaller motor size, and improved reliability. However, the control flexibility available with these drives is limited and their application is, in the main, restricted to fan, pump, and compressor types of applications where the speed need be regulated only roughly and where transient response and low-speed performance are not critical.

More demanding drives used in machine tools, spindles, high speed elevators, dynamometers, mine winders, rolling mills, glass float lines, and the like have much more sophisticated requirements and must afford the flexibility to allow for regulation of a number of variables, such as speed, position, acceleration, and torque. Such high-performance applications typically require a high speed holding accuracy better than 0.25%, a wide speed range of at least 20:1, and fast transient response, typically better than 50 rad/s, for the speed loop. Until recently, such drives were almost exclusively the domain of DC motors combined with various configurations of AC-to-DC converters depending upon the application. With suitable control, however, induction motor drives have been shown to be more than a match for DC drives in high-performance applications. While control of the induction machine is considerably more complicated than its DC motor counterpart, with continual advancement of microelectronics, these control complexities have essentially been overcome. Although induction motors drives have already overtaken DC drives during the next decade it is still too early to determine if DC drives will eventually be relegated to the history book. However, the future decade will surely witness a continued increase in the use of AC motor drives for all variable speed applications.

AC motor drives can be broadly categorized into two types, thyristor based and transistor based drives. Thyristors posses the capability of self turn-on by means of an associated gate signal but must rely upon circuit conditions to turn off whereas transistor devices are capable of both turn-on and turn-off. Because of their turn-off limitations, thyristor based drives must utilize an alternating EMF to provide switching of the devices (commutation) which requires reactive volt-amperes from the EMF source to accomplish.

A brief list of the available drive types is given in Figure 1.1. The drives are categorized according to switching nature (natural or force commutated), converter type and motor type. Naturally commutated devices require external voltage across the power terminals (anode-cathode) to accomplish turn-off of the switch whereas a force commutated device uses a low power gate or base voltage signal which initiates a turn-off mechanism in the switch itself. In this figure the category of transistor based drives is intended to also include other hard switched turn-off devices such as GTOs, MCTs and IGCTs which are, in reality, avalanche turn-on (four-layer) devices.

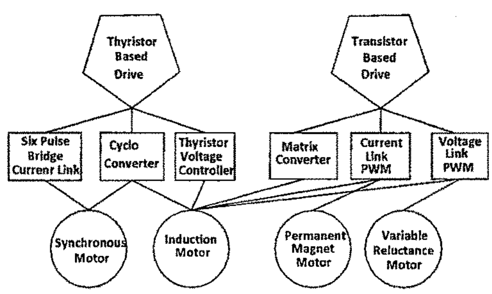

Figure 1.1 Major Drives type categories

The motion control used in various industries is shown in table 1.1

Table 1.1 Industrial Applications where motion control is require		
Sr. No.	INDUSTRY	APPLICATION
1	Automotive and transport equipment	Conveyer, marine, pumps
2	Chemicals and pharmaceuticals	Centrifugal pumps, fans, filling machine, labeling machine
3	Electronics ,electric and cables	Conveyors ,vacuum pump, winders
4	Food and beverage	Centrifugals ,agitators, pumps

Cont.

5	Metal working	Saws ,lathes, drills ,grinders presses, flying tools ,indexers, punchers, cranes
6	Material handling, lifts and cranes	Conveyors, hoists, screw feeder, cranes and lips
7	Metals ,minerals and mining	Dregs ,conveyors ,crusher ,ovens, smelters, and rolling mills
8	Oil ,gas and energy	Separators, conveyor and fans and pump
9	Packing machinery	Pelletizes high rise store, foil wrappers
10	Paper and printing	Pumps, wood chippers, washers, winders, printers, paper and cardboards lines,
11	Stone ,clay and glass	Conveyors, grinders, crushers, ovens, palletizers,
12	Textile and fiber	Man-made lines, cards, spinning frames, winders, weaving and knitting machine, cutting machine
13	Wood working	Sawmills, lathes, plywood lines, conveyor, indexers

In chapter 3 various methods used for controlling the speed of an induction motor is discussed also the problems associated with them are discussed.

As depicted in figure 1.1 current source inverter and voltage source inverter are being used for controlling speed of an induction motor. In this method motor winding is subjected to number of pulses per second. The effect of these pulses on motor winding is discussed in chapter 4. In chapter 5 MATLAB/SIMULINK program is presented for conducting No Load and Locked Rotor test on an induction motor.

Chapter 6 describe the detail of motors manufactured for the study purpose, experimental setup and voltage wave forms recorded during experiments for sinusoidal 50 Hz utility supply and with IGBT base PWM inverter supply with different frequency.

Discussion on wave forms obtained during experimentation is presented in chapter 7. How to improve the motor insulation performance is also discussed in this chapter.

Conclusion derived from the work and suggestions for possible direction for extension and scope for the enhancement are discussed in chapter 8.