# CHAPTER ONE
# INTRODUCTION

## 1.1General Concept:

Three-phase induction motors are so common in industry that in many plants no other type of electric machines can be found. This simple and robust machine, an ingenious invention of the late nineteenth century, still maintains its unmatched popularity in industrial practice.

Induction motors employ a simple but clever scheme of electromechanical energy conversion. In the squirrel-cage motors, which constitute a vast majority of induction machines, the rotor is inaccessible. No moving contacts, such as the commutator and brushes in dc machines or slip rings and brushes in ac synchronous motors and generators, are needed. This arrangement greatly increases reliability of induction motors and eliminates the danger of sparking, permitting squirrel-cage machines to be safely used in harsh environments, even in an explosive atmosphere. An additional degree of ruggedness is provided by the lack of wiring in the rotor, whose winding consists of uninsulated metal bars forming the "squirrel cage" that gives the name to the motor. Such a robust rotor can run at high speeds and withstand heavy mechanical and electrical overloads. In Adjustable-Speed Drives (ASDs), the low electric time constant speeds up the dynamic response to control commands. Typically, induction motors have a significant torque reserve and a low dependence of speed on the load torque.

The less common *wound-rotor* induction motors are used in special applications, in which the existence and accessibility of the rotor winding is an advantage. The winding can be reached via brushes on the stator that ride atop slip rings on the rotor. In the simplest case, adjustable resistors (rheostats) are connected to the winding during startup of the drive system to reduce the motor current. Terminals of the winding are shorted when the motor has reached the operating speed. A price is paid for the extra possibilities offered by wound rotor motors, as they are more expensive and less reliable than their squirrel-cage counterparts. In today's industry, wound-rotor motors are increasingly rare, having been phased out by controlled drives with squirrel-cage motors. Therefore, only the latter motors will be considered in this research. Although operating principles of induction motors have remained unchanged, significant technological progress has been made over the years, particularly in the last few decades. In comparison with their ancestors, today's motors are smaller, lighter, more reliable, and more efficient.

The so-called *high-efficiency motors,* in which reduced-resistance windings and low-loss ferromagnetic materials result in tangible savings of consumed energy, are widely available. High-efficiency motors are somewhat more expensive than standard machines, but in most applications the simple payback period is short. Conservatively, the average life span of an induction motor can be assumed to be about 12 years (although properly maintained motors can work for decades).

## 1.2 Motivation:

Three phase induction motors are used in industry for converting electrical power into mechanical power. They are considered to be simple, rugged, robust, effcient, and suitable for applications in harsh environments. However, despite their popularity, their controllability remains a difficult task using conventional control methods. The control difficulty is associated with high nonlinearity of the motor’s behaviour, complexity of its analytical model and presence of interactive multivariable structures. Therefore, designing a conventional controller takes significant time and effort and requires the presence of an accurate model of the motor.

In recent years, the advances in power electronics and computing fields have made it possible to use three phase induction machines in high performance applications [1]. Also, more robust and intellignt controllers have been employed for induction motor control. One of those intelligent controller is the Fuzzy Controller. Fuzzy controllers allow the human experience to be incorporated in the control process [2].

Fuzzy controller, unlike conventional ones, can be designed without the need for an accurate model or with less information about the controller system, which applies in the induction motor’s case. FLC offers a linguistic approach to develop control algorithms for any system. It maps the input-output relationship based on human expertise and hence, does not require an accurate mathematical model of the system and can handle the nonlinearities that are generally difficult to model. This consequently makes the FLC tolerant to parameter variation and more accurate and robust[3]. The vector control or field oriented control (FOC) theory is the base of a special control method for induction motor drives. With this theory induction motors can be controlled like a separately excited dc motor [4]. This method enables the control of field and torque of the induction machine independently (decoupling) by manipulating the corresponding field oriented quantities.

## 1.3 Thesis Objectives :

The main objectives of this research can be summarized **as follows:**

- To develop a mathematical and SIMULINK/MATLAB models of IFOC for the induction motor drive controlled by a fuzzy controller.
- To test drive system performance (Rising time, overshoot, time to the peak, and settling time ) under various numbers of input/output fuzzy membership functions.
- To compare the drive performance using different membership functions using a proposed measure under speed step change and load disturbance.
- To compare the drive performance using fuzzy controller with other type of conventional control.

- To implement the control in real time.

## 1.4 Methodology:

In this thesis the control of induction motor drive is based on vector control, which is quite different from scalar control. The torque and flux are controlled by acting on both magnitude and position of the space vectors of the voltages and currents. Vector control is a general philosophy that can be applied in different ways. Field oriented control is a kind of vector control, which acts on the angle between the current and flux to make the induction motor to emulate a separately excited DC machine.

Direct field orientation was introduced by Blaschke. He used two Hall Effected sensors mounted in the air gap to estimate the rotor flux based on the air gap measurement. Since it was not desirable to install flux sensors in the motor air gap, the Indirect Field Orientation Control (IFOC) approach is introduced. This approach estimates the rotor flux from the measured currents and speed without the need for flux measuring sensors.

Fuzzy controller of Mamadani type uses both the speed error and its rate of change as inputs, and the electromagnetic torque as output. The Proposed Fuzzy Controller in this thesis will be designed and simulated using MATLAB TOOL BOX.

## 1.5 Thesis Structure:

The thesis is presented in nine chapters:

**Chapter one** gives an introduction to the research, including: general concept, motivation, objectives of research and methodology.

**In chapter two**, a general characterization of induction motors and their use in ac drive systems is given. Common mechanical loads and their characteristics are presented, and the concept of operating quadrants is explained. Control methods for induction motors are briefly reviewed. Construction and operating principles of induction motors are presented in this chapter. The generation of a revolving magnetic field in the stator and torque production in the rotor are described. The per-phase equivalent circuit is introduced for determination of steady-state characteristics of the motor. In this chapter, we will discuss the principles of FL. The Fuzzy Logic Toolbox in the MATLAB environment.

**In chapter three**, operation of uncontrolled induction motor drives is examined. We briefly outline methods of assisted starting. In this chapter, we review power electronic converters used in ASDs with induction motors. Various types of rectifiers providing the dc supply voltage for inverters feeding the motors are presented, and we describe voltage source inverters, and current source inverters. Control methods for inverters, with a stress on the use of voltage space vectors, are illustrated.

**Chapter four** introduces two-inductance, Γ and Γ', per-phase equivalent circuits of the induction motor for explanation of the scalar control methods. The open-loop, Constant Volts Hertz is presented, and field weakening and compensation of slip and stator voltage drop are explained. Finally, scalar torque control, based on decomposition of the stator current into the flux-producing and torque producing components, is described.

**In Chapter** five, we define and illustrate space vectors of induction motor variables in the stator reference frame, dq. Dynamic equations of the induction motor are expressed in this frame. The idea of a revolving reference frame, DQ, is introduced to transform the ac components of the vectors in the stator frame into dc signals, and formulas for the straight and inverse abc→dq and dq→DQ transformations are provided. We explain adaptation of dynamic equations of the motor to a revolving reference frame. This chapter presents a review of conditions of production and control of torque in the dc motor. Principles of the field orientation in the induction motor are introduced, and the direct and indirect field orientation schemes utilizing the rotor flux vectors are presented.

**Chapter six** evaluates the performance of fuzzy controller and provides a series of simulations and a comparative study between the performances of fuzzy controller and those of conventional control types, and the results are discussed.

**Chapter seven** shows the effect of some fuzzy controller parameters on IFOC of an IM. Those parameters include the shape and number of membership function (MFs).

**Chapter eight** deals with implementation of fuzzy controller.

**Chapter nine** draws general conclusions from the research and provides recommendations for further research work in this area.